IS A ROBOT AN APPLIANCE, TEAMMATE, OR FRIEND? AGE-RELATED DIFFERENCES IN EXPECTATIONS OF AND ATTITUDES TOWARDS PERSONAL HOME-BASED ROBOTS

A Dissertation
Presented to
The Academic Faculty

By

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In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Philosophy in Psychology

Georgia Institute of Technology

December, 2008

IS A ROBOT AN APPLIANCE, TEAMMATE, OR FRIEND? AGE-RELATED DIFFERENCES IN EXPECTATIONS OF AND ATTITUDES TOWARDS PERSONAL HOME-BASED ROBOTS

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To Eli, my motivator

ACKNOWLEDGEMENTS

Firstly, I would like to thank my committee members, Dan, Greg, Irfan, Jim, Koert, and Wendy, for their excellent and through feedback. I would also like to thank Marita, Jenay, and Kathi. I would not have been able to finish this work without their help. Finally, I would like to thank my parents for their support and love, Steven for his patience, and Ruby for making me happy.

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SUMMARY

Future advances in technology may allow home-based robots to perform complex collaborative activities with humans. One user group that could greatly benefit from these robots is the older adult population. Potentially, robots could work with older adults to accomplish goals of everyday living and allow older adults to continue living independently in their home.

Although advanced personal home-based robots may not be available to consumers for several years, it is critical that the current expectations that individuals' have about home-based robots be examined. Expectations and attitudes towards new technology can often predict future use of that technology (Compeau, Higgins, & Huff, 1999). However, current models of technology acceptance, such as the technology acceptance model (TAM; Davis, 1989) may not capture the social or team-type interactions that users could expect to have with robots. There is a need to identify the factors that capture individuals' expectations of robots and investigate if these factors predict their attitudes towards robots. These factors may be different for younger and older adults.

Two studies were conducted to understand the expectations of and attitudes toward home-based robots by younger and older adults. One study involved questionnaires sent to 2500 younger adults (aged 18-28) and 2500 older adults (aged 65-86) in the Atlanta Metropolitan area. One hundred and eighty questionnaires were completed and returned by individuals in the targeted age groups. For the questionnaire,

participants were asked to imagine a robot in their home and then to answer questions about how well characteristics matched their imagined robot. The characteristics were machine/appliance-, teammate-, or social-related variables. Participants were also asked to indicate the strength between their envisioned robot and overall role descriptions (e.g., appliance, friend, and teammate), answer questions related to TAM variables (i.e., usefulness and ease of use; attitudinal acceptance and intentional acceptance of robot), and indicate their willingness to have the robot perform 15 different tasks (e.g., teach me a new skill). Participants' technology and robot experience, demographic information, and health information were also collected.

In conjunction with the questionnaire study, twelve younger adults (aged 19-26) and twenty-four older adults in two older age groups (younger-older, aged 65-75, and older-older aged 77-85) were interviewed about their expectations of and attitudes toward a robot in their home. The participants were first asked questions about how they define a 'robot'. They were then asked to imagine a robot in their home and answer numerous questions about the tasks their envisioned robot would perform, the appearance of the robot, and other general questions about their interaction with the robot. Following this, participants were asked to envision different robots for entertainment, health-related, and security tasks. They answered a series of four questions about each type of robot. The interview concluded with questions about the negative characteristics of robots, considerations before purchasing a robot, anticipated lifestyle changes with a robot, and changes in opinions about robots throughout the interview. After the interview, participants answered questions about their technology and robot experience.

There were several interesting results from the studies. For the questionnaire study, participants varied in how human-like and how machine-like they imagined a robot in their home to be, although the overall tendency was to imagine a more machine-like device. Younger adults, however, were more likely than older adults to ascribe human-like characteristics to their robot. A factor analysis on robot characteristic factors suggested three ways that participants imagined a robot in their home: most often as productive, secondly as social, and least of all as uncontrollable. Participants also thought of a robot more in a supportive role, as an assistant or teammate, rather than in a role equal to a human or in a role with unclear functionality, such as a pet or toy. The results of the questionnaire also suggested that participants' expectations about the usefulness and ease of use of a robot were most predictive of their attitudes towards a robot and their indicated intention to purchase a robot for their home. They were more willing to have robots perform more critical, albeit infrequent tasks, over less critical but more frequent tasks that required more interaction with the user. In general, there were few age-related differences in participants' expectations and attitudes towards a robot in their home when differences in experience with technology were accounted for. The results suggest that more experience with technology, regardless of age, is related to more positive views about a robot in the home.

The results of the in-depth interview study were also quite informative. Participants tended to define robots as machines that perform tasks typically performed by humans. They generally imagined that a robot in their home would perform cleaning and organizing tasks because these were tasks they saw as time-consuming and boring. Older adult participants also imagined that a robot could help them perform tasks that were currently difficult or would be difficult in the future. When exposed to other types of tasks that a robot could do in the home- entertaining, health-related, and security tasks- participants' attitudes about those robots tended to match how much benefit they thought the robot would be to themselves and others. In general, participants thought of a robot as an appliance that was in the home for specific purposes. They did not see a need for robots to be continuously active or very interactive. There was also evidence that younger adults were more comfortable than older adults in leaving a robot alone in the home; older adults were more likely to think that a robot would need to be monitored. Finally, participants indicated that they would want to know about a robot's capabilities before getting one for their home. They would not want a robot that was intrusive or disruptive, uncontrollable, or difficult to maintain.

The results of the studies suggest that individuals have many different ideas about what a robot in the home would be like. Mostly, they want a robot to perform mundane or repetitive tasks, such as cleaning, and picture a robot as a time-saving device. However, individuals are willing to have a robot perform other types of tasks, if they see benefits of having the robot perform those tasks. The ability of the robot to perform tasks efficiently, with minimal effort on the part of the human, appears to be more important in determining acceptance of the robot than its social ability or appearance. Overall, individuals both younger and older seem to be very open to the idea of a robot in their home…as long it is useful and not too difficult to use.

INTRODUCTION

The past few years have demonstrated that home-based robots can be viable commercial products (United Nations Economic Commission/International Federation of Robotics, 2005). Although the majority of currently available home-based robots are designed for household tasks such as vacuuming or used for entertainment, there is a growing trend to develop robots that are more than servants, high-tech appliances, or toys. These more intelligent robots of the future may function as active partners with humans in tasks involving healthcare and educational domains (Dautenhahn, Woods, Kaouri, Walters, Koay, & Werry, 2005). In addition, it is likely that these robots will be able to adapt to support the needs of their users, essentially becoming personalized social teammates.

One population that may be especially influenced by the increase in home-based robots is the older adult population. Whereas the population of older adults is expected to increase dramatically in the coming years, approximately 1 out of 6 persons throughout the world will be over the age of 65 by 2050 (UN, 2002), the healthcare sector is not expected to grow at nearly a fast of a rate (Zweifel, Felder, & Meiers, 1999). The inability of the healthcare sector to keep up with an aging population opens up an opportunity to develop technology that can augment some roles of a nurse or health-assistant. A home-based robot may fill a role that, unlike other assistive device, allows for a complex social exchange between user and system. This social interaction may be especially important when the goal is to help older adults perform health and self-care tasks for disease management—tasks that require older adults to be convinced to make positive health-related changes to their lifestyle. A robot may also help older adults perform tasks that are difficult for them to due to age-related declines in physical and cognitive abilities.

As assistive devices are only beneficial if they are actually used, a robot, if designed appropriately, may engage the older user and lead to increased use. The key words here, of course, are “if designed appropriately”. At this point the critical variables that will lead older adults to accept and use robots effectively are not fully understood. As acceptance of new technology is largely influenced by expectations of the technology (Davis, 1989), the expectations that older users may have of robots and whether these may or may not reflect the actual abilities and limitations of robots, is of particular concern. Thus one purpose of the proposed studies is to begin to understand the expectations that older adults have about home-based robots to allow gaps between expectations and reality to be identified.

From Traditional Robots to Personalized Home-Based Robots

The traditional robot is a purely task-driven machine. Sheridan (1992), for example, defined a *robot* as a reprogrammable “manipulator” containing sensors, effectors, memory, and some real-time computational apparatus, designed to perform tasks, such as moving materials, parts, tools, or specialized devices, through various pre-specified motions. In this sense, the robot is a type of machine that perceives information in the world, selects among pre-specified actions based on that information, and then acts on the world in a largely predictable way. Although there are many tasks that benefit from a traditional robot, such as those requiring precision, timing, and coordination, there are other tasks that would benefit more from the collaboration of human and robots, such as those that require flexibility and problem-solving (Fong, Thorpe, & Baur, 2003).

A home-based robot could be seen as a more personalized robot than a traditional robot found in a factory or assembly plant. Unlike a traditional robot, a home-based robot could not only be task-oriented but also socially-oriented. Instead of using static models to perform preprogrammed actions, a home-based robot could operate on abstract and adaptable models of the world based on its social interaction with humans. Dario, Guglielmelli, and Lasche (2001) proposed that personal robots for the home are the final step in the evolution of robots. According to Dario et al., although personal robots have been depicted in science fiction movies and books for many years, until recently robots have mainly been used in industrialized settings and manufacturing; they have required stable and structured environments. To feasibly create personal robots that can adapt for personal use in the unstructured and unstable domestic environment has required several intermediate steps representing innovations in robotics. These steps in the evolution of personal robots include, in evolutionary order: 1) advanced robots that can be used in unstructured environments without humans in close proximity, such as those in scientific exploration and construction-type applications, 2) service robots that can function in unstructured working environments in which a person is present, such as vacuuming robots, and 3) human-friendly robots that cooperate with humans to perform tasks in unstructured working environments, such as robots built as museum guides. Personal robots represent the next objective: Robots that are adaptable for personal use in home-based applications, including robots for healthcare, companionship, education, and for other human-centered applications.

It is unknown whether individuals expect robots in their homes to be more like traditional robots, more like personalize and socially-oriented robots of the future, or somewhere in between. Thus a major goal of the present research was to understand whether individuals imagine a robot in their home as more task-oriented, suggesting a more machine-like robot, or more socially-oriented, suggesting a more human-like robot.

Acceptance of Robots

As the concept of a home-based robot implies personal use, a critical issue that emerges is user acceptance. Whereas for industrial robots, the success of design can largely be measured by objective measures, such as speed, precision, and reliability, the success of design for the personal robot will likely be combination of user-based subjective criteria, human-robot team performance, and behavioral measures such as compliance and reliance.

In considering the factors that may influence user acceptance of personal robots, first it is important to identify what acceptance is. According to the Technology Acceptance Model (TAM), acceptance of technology is a combination of attitudinal, intentional, and behavioral acceptance (Davis, 1989). Attitudinal acceptance is defined as a person accepting a product in principle; that is, the person has developed general positive beliefs about the product after evaluating information he or she has about it. Intentional acceptance is defined as a person having the intent to act in a certain way with the product, typically intention to buy or use the product. Behavioral acceptance is defined as a person taking action in acquiring and/or using the product.

TAM is a forward-looking model of prospective expectations about information technology usage. In general it is believed that attitudes about a technology, particularly perceived usefulness and perceived ease of use, influence consumers' intentions to buy or use the technology, which in turn influences their behavior to acquire and use the technology (Davis, 1993). There is strong empirical support for TAM (Karahanna, Straub, & Chervany, 1999; Venkatesh & Davis, 2000; Venkatesh, Morris, Davis, & Davis, 2003). Perceived usefulness appears to be a stronger predictor of acceptance than perceived ease of use although the two are typically correlated (Hu, Chau, Sheng, & Tam, 1999; Subramanian, 1994).

Attitudinal acceptance of home-based robots is particularly interesting because such a robot would likely be a disruptive technology; more of an innovation than a natural progression of home-based technologies. Radical technologies are often not attitudinally accepted as readily as incremental innovations (Dewar & Dutton, 1986; Green, Gavin, & Aiman-Smith, 1995). "New" technologies may be perceived as complex and hold more uncertainty, both in their benefit, and in their performance ability (Hoeffler, 2003). In addition, robots have been presented in science fiction books and movies in both positive ways (e.g. Rosie on *The Jetsons*) and in negative ways (e.g. the Terminator in *The Terminator* movies). So although few individuals may have interacted with a real robot, they may have existing expectations of how a robot may look, behave, and interact with them.

Predicting attitudinal acceptance of personal robots is complicated because these robots are expected to have socially-complex interactions with humans. The dual role of the personal robot as both a task-directed and a socially-directed machine suggests that existing models of technology acceptance may not sufficiently capture robot acceptance. Although research has shown that individuals may perform a cost/ benefit analysis of technology (Dishaw & Strong, 1999; Van Schaik, Flynn, Van Wersch, Douglass, & Cann, 2004), it is unclear as to how expectations of robots' social ability enter into this analysis. For one thing, it is unknown whether individuals will put equal consideration in what they perceive the robot can do task-wise and what it can do socially-wise. If personal robots are thought of simply as a type of technology, then individuals' attitudinal acceptance may be captured by perceived ease of use, perceived usefulness, and expected system performance. If they are thought of as social creatures, then attitudinal acceptance may be captured more by factors important in social and team interactions, such as personality, affects, and motivations (O'Shea, Driskell, Goodwin, Zbylut, & Weiss, 2004). Hence, to understand individuals' attitudinal acceptance of personal robots would require the underlying factors of acceptance to be revealed.

Why should we care about attitudinal acceptance of robots? If robots are designed to be placed in homes, it is important that they be designed in such a way that individuals have appropriate expectations of what they can and cannot do. Ideally, there should be a match between individuals' expectations of robots and reality (Fong, Thorpe, & Baur, 2003). Perfect calibration between expectations and reality may lead to optimal use of robots. According to Breazeal (2003), in designing personal robots, the question is not whether people will use a social model to understand robots and develop plans for interacting with them, but rather how well robots adhere to these social models. Therefore, it is important to understanding individuals' existing mental models of home-based robots; this understanding may lead to ways that individuals' mental models can be modified or refined to more accurately represent the actual abilities and limitations of robots.

Expectations of Robots

Individuals may have different expectations of the form and behaviors of home-based robots. Nomura, Kanda, Suzuki, and Kato (2005), suggested that the different images of robots in people's minds may affect their attitudinal acceptance of robots. Research concerning expectations of and attitudes towards robots has looked at individuals' fear of robots as well as more general expectations of robots, either as companions or as servants.

Fear of robots. Fear of robots has been assumed by some as a barrier to introducing robots in the home. A historical review of mythology in Western society reveals a trend towards fear of robot-like machines because they are entities that blur the line of nature and culture (Kaplan, 2004). Socially intelligent robots, in particular, may be feared because they are too human-like. This fear is captured by a prominent theory in human-robot-interaction called the "uncanny valley". The uncanny valley, first proposed by Japanese roboticist Masahiro Mori in 1970 (as cited in DiSalvo, Gemperle, Forlizzi, & Kiesler, 2002), suggests that as a robot increases its human-likeness, it is increasingly accepted up until a critical point. This critical point, or uncanny valley, is when the robot is very realistic but with subtle mistakes that make it too disturbing for acceptance (i.e., like a moving corpse). Some evidence for the uncanny valley comes from Woods, Dautenhahn, and Schulz, (2004) who found that children associated a robot's ability to have feelings with how human-like it looked, but viewed robots that were extremely human-like as very aggressive and unfriendly. Hence, if individuals' mental models of robots fall in the uncanny valley region of human-likeness, this may be associated with a general fear of or discomfort with robots.

Under the assumption that individuals will be fearful of robots, albeit differentially fearful, several studies have examined individual differences in negative attitudes towards robots. Nomura, Kanda, Suzuki, and Kato (2004) attempted to create a psychological scale to measure human emotions that develop when interacting with a specific robot. They conducted a pilot test, in which Japanese university students interacted with a robot for one minute in a guidance task. Following this, the students were asked about whether they felt anxiety from the interaction, and if so, where this anxiety came from. They were also asked about their anxiety with robots in everyday life. The results were that half of the participants reported having anxiety with the specific robot they interacted with and almost all indicated feeling anxious when they imagined robots in everyday life. Different types of anxiety mentioned included anxiety towards the motion or approach of robot, their unpredictability, and the way they interact with humans. Other concerns about robots in everyday life included those about the trouble that robots can cause, their reliability in practical situations, and their social influence.

The results of the Nomura et al. (2004) study were used to develop the 14-item Negative Attitude towards Robots Scale (NARS) questionnaire. Questions on the NARS ask respondents about negative attitudes (i.e., anxiety, nervousness, fear, and helplessness) towards robot-interaction, the social influence of robots, and robot emotions during interaction. The questionnaire has largely been used to investigate cross-cultural differences in negative attitudes towards robots. For instance, the NARS has been used to demonstrate that Japanese university students may have more concerns about robots than Dutch or Chinese students (Bartneck, Nomura, Kanda, Suzuki, & Kato, 2005) and individuals in the United States may have fewer negative attitudes towards robots than individuals living in China, Germany, Japan, Mexico, and The Netherlands (Bartneck, Suzuki, Kanda, & Nomura, 2007). In addition, Bartneck et al. (2007) found that across several countries, females and individuals who had experience with Sony's AIBO robotic dog, had fewer negative attitudes towards robots than males and individuals without experience with AIBO. Although results from NARS-based studies are interesting, in that they suggest the presence of group differences in attitudes towards robots, the questionnaire does not allow for the underlying reasons for these differences to be investigated.

The NARS questionnaire has not demonstrated itself to be a good predictor of behavioral acceptance of a specific robot. Individuals that score high on anxiety and those that score low on anxiety towards robots have been found to act almost identically towards an unfamiliar robot, with the only difference being high anxiety group taking longer to initiate conversation with the robot (Nomura, Kanda, & Suzuki, 2004). Along with additional evidence that individuals are more likely to indicate the idea of robots as positive rather than as frightening (Khan, 1998) suggests that individuals' fear of robots may only capture a proportion of influences on acceptance of robots. There may be other, more critical factors that may determine acceptance.

General expectations of and attitudes toward robots. Other investigations of expectations of and attitudes toward robots have looked less at fear of robots and more about what individuals want robots to do. Dautenhahn, Woods, Kaouri, Walters, Koay, and Werry (2005) had young and middle-aged participants interact with a human-sized, but mechanical-looking, robot in a simulated living room. The participants were given a questionnaire about their attitude towards a robot companion, which tasks they thought robots should do, and their attitudes towards computers in general. Less than half of participants indicated that they liked the concept of a robot companion compared to a majority indicating that they liked computers and computer-related technology. In response to what roles participants thought a robot should have, the majority said assistant or machine/appliance and slightly less than half said servant. A small percentage of younger participants said friend/companion but none of the middle-aged participants said this. Participants were asked what tasks robots in the future should be able to perform. Almost all participants mentioned household jobs such as vacuuming and more than half mentioned entertaining, gardening, and security. A very small percentage mentioned taking care of their children. When asked about what behavior traits a robot companion should have, predictability was mentioned by a majority of respondents. Although participants indicated that they wanted communication with a robot to be human-like, a far smaller percent thought it should behave like a human or look like a human.

In another questionnaire study, Khan (1998) looked at attitudes towards robots as intelligent servants. The questionnaire contained questions about which tasks respondents would like a service robot to help them with, how they would like to communicate with a robot, and how independent they thought robots should be. The questionnaire was distributed to individuals 21-60 years old in Sweden. The tasks that respondents indicated that would allow a robot to help them with were polishing windows, cleaning ceiling and walls, general cleaning, wet-cleaning, and moving heavy things. The respondents generally did not want a robot to help them with tasks such as babysitting, reading aloud, watching their pet, performing tasks of a butler, cooking food, and taking care of kitchen goods. When asked how they would want to communicate with robot, speaking was selected as the preferred method. In response to how independent robots should be, most participants thought all robot commands should be preprogrammed. Thus, the general findings from Khan (1998) were that although individuals had a generally a positive attitude towards intelligent service robots, mostly wanted them to perform tedious and time consuming tasks and thought they should be highly controllable.

The results from Dautenhahn et al. (2005) and Khan (1998) suggested that individuals generally expect robots to be advanced appliances and are largely concerned with the predictability of robots. The studies, however, do not completely address the factors that predict attitudinal acceptance of robots, such as perceived usefulness and social intelligence. Furthermore, the studies do not address older adults' expectations of and attitudes towards robots.

Robots and Older Adults

In recent years there has been an increasing interest in designing technology that helps older adults perform activities that allow them to continue living independently in their own homes (Mynatt, Essa, & Rogers, 2000). These assistive systems are often designed to keep individuals safe in their home (assurance systems), those that support everyday activities that have become difficult due to cognitive or physical decrements (compensation systems), and those that track individuals' abilities by tracking activities over a period of time (assessment systems; Pollack, 2005). Although home-based robots may be able to fill all of these roles, they are likely to be most beneficial as compensatory systems. This may be because robots with high social intelligence may provide an especially engaging and intuitive interface that encourages their use. As compensatory systems, home-based robots may help older individuals remember schedules, comply with medication regiments, and learn how to use other types of technology. These are the types of tasks that researchers at Carnegie Mellon University and the University of Pittsburgh are attempting to design into an assistive nurse-robot named Pearl (see http://www.cs.cmu.edu/~nursebot/). Robots such as Pearl could have applications that older adults, or even individuals of other age groups, may not expect robots to perform.

Although robots may provide many benefits to older individuals, it is unknown whether older adults would be willing to accept robots in their home. In general, age appears to be negatively related to new product acceptance (Kelley & Charness, 1995; Zajicek & Hall, 2000). With computers, for example, older adults perceive less comfort, efficiency, and control (Czaja & Sharit, 1998). Older adults may be especially concerned about the user-friendliness of technological devices and the need for training (Demiris et al., 2004). When older adults do use new technology they tend to use it in an old way, for example by using a cell phone to make calls, compared to younger adults who may use new technology in a new way, for example by using a cell phone to take pictures and to send text messages (Morris & Venkatesh, 2000).

The slower adoption of new technology of older adults, compared to younger age groups, may be due to changes in abilities and motivations that occur with age. Differences in cognitive ability, computer self-efficacy, and computer anxiety may mediate the relationship between age and adoption of technology (Czaja et al. 2006). However, there is also evidence that older adults are willing to accept technology if they see the benefit of it (Caine, Fisk, & Rogers, 2007; Melenhorst, Rogers, & Bouwhuis, 2006; Sharit, Czaja, Perdomo, & Lee, 2004). If older individuals perceive the usefulness of robots, they may be willing to accept them.

Only a few studies have investigated older adults' acceptance of robots. Some of these studies have looked at the general responses of older adults to specific robots. Montemerlo, Pineau, Roy, Thrun, and Varma (2002), for instance, found that older adults were excited after interacting with a nurse-robot that helped them navigate through a building. Wada, Shibata, Saito, and Tanie (2004) found that the mood of older Japanese women in an elderly care facility increased after interaction with a robotic seal named Paro. These studies, although demonstrating that older adults may accept specific robots under certain circumstances, do not help to uncover *why* or *when* older adults may accept robots or if they would be willing to accept them in their own homes.

One reason that older adults may be willing to accept robots may be robots' social intelligence. Heerink, Kröse, Evers, and Wielinga (2006) used a Wizard of Oz technique to create a more social and less social robot that interacted with older adults in an elderly care facility. The robot could be instructed to set an alarm, give directions to the nearest supermarket, and give tomorrow's weather forecast. The properties of the more social robot included looking at the participant, apologizing if the participant said it made a mistake, being facially expressive, remembering the participant's name and using it, nodding and blinking, and being polite by waiting until the participant finished talking before talking. The researchers found that older adults were more expressive with the more social robot than with a less social one, for instance they nodded their head more, smiled more, and laughed more. Although the results of the study by Heerink et al. implied that older adults may be more willing to accept a more socially intelligent robot, the results are far from conclusive.

An important consideration in developing home-based robots for older adults is that the home is often an already established social space to which the robot is being added. When technology is placed in a home, an often complex and dynamic setting, there will undoubtedly be social consequences (Dewsbury, Clarke, Rouncefield, Sommerville, Taylor, & Edge, 2003). Older adults may be particularly concerned with how robots would fit harmoniously in the socio-physical home environment (Scopelliti, Giuliani, & Fornara, 2005). It is unclear whether older adults will perceive a robot as fitting into the existing social structure or only disrupting it.

To summarize: Older adults have the potential to benefit from robots that help them to compensate for age-related decrements in cognitive, perceptual, and physical abilities. However research on acceptance of robots by older adults has been minimal. Because so little is known about older adults' expectations of and attitudes towards personal home-based robots, it is crucial that this area of research be explored. Moreover, because personal robots may have the characteristics of technology/machines, social partners, and teammates, all three of these areas should be examined in respect to older adults' expectations of robots. Differences in expectations between younger and older adults should also be noted and accounted for; for example by comparing technology and robot experience as they relate to the willingness of individuals to have robots perform different types of tasks in their home.

Overview of Studies

Two exploratory studies were conducted to understand older and younger adults' expectations of and attitudes toward a robot in their home: a survey study and an in-depth interview study. The approaches were selected to represent both qualitative and quantitative research, a useful approach when used to explore an area about which little is known (Strauss & Corbin, 1990). More specifically, the survey approach was used to investigate statistical relationships between age, beliefs about a robot in the home, technology experience, and attitudinal and intentional robot acceptance. The interview approach was used to support findings from the survey study and gain further insight into these finding by gathering in-depth information from younger and older adults that could not be obtained from a questionnaire alone.

For the survey study, questionnaires were sent to younger and older adults living in the Atlanta Metropolitan area and surrounding counties. The questionnaire was designed to uncover the factors that capture the prototypical characteristics of home-based robots and examine these factors in relationship to technology acceptance model (TAM) variables, technology and robot experience, and age. Concurrently to the questionnaire study, another study utilized interviews with younger and older adults to understand their expectations about home-based robots in more depth. Participants were asked to define robots, imagine a robot in their home, and answer questions about their envisioned robot. They were also asked questions about three robot task domains (entertainment, health-related activities, and security), and describe the information they would need to have before obtaining a robot for their home.

The two studies were conducted in parallel, and will be discussed separately. The general themes will be integrated in the discussion.

CHAPTER 2: QUESTIONNAIRE METHOD

Sample

Questionnaires were mailed to 5000 individuals in the Atlanta Metropolitan area and surrounding counties. The sample was drawn from an age-targeted list acquired from a survey sampling company. The survey sampling company derived names in its 65-million person database by using voter registration information, magazine subscriptions, and other sources to predict the incidence that a person matched the age criteria. The hit rate of finding a person in the specified age range was 65%. The age criteria specified for this sample was younger adults (aged 18-28) and older adults (aged 65-85); 2500 questionnaires were sent to younger adults and 2500 to older adults.

Materials

Participant Packets

Each participant packet consisted of seven items: 1) cover letter 2) informed consent, 3) initial questions sheet (blue sheet), 4) questionnaire, 5) sweepstakes entry form, 6) checklist for return mailing, and 7) pre-paid envelope with return address.

Cover Letter

The cover letter informed recipients of the purpose of the study: To understand what people expect robots in their home to be like and possible age differences between these expectations. The letter further informed recipients about how their names were selected, how to keep their questionnaire anonymous, how long they should expect the questionnaire to take (45-90 minutes), and what they would need to do to enter the sweepstakes and receive a summary of the results. The cover letter that was sent to participants is available in Appendix A.

Initial Questions Sheet

Initial questions for questionnaire recipients were printed on a separate blue sheet (the blue sheet was also labeled “blue sheet” for easy recognition). Participants were instructed to answer the questions on the blue sheet first. The directions printed on the blue sheet instructed participants to imagine that someone has given them a robot and to form a picture in their mind about what this robot would look like, behave like, and do in their home. The first question on the blue sheet asked participants to describe the robot they imagined in their home. The second question asked participants to draw the robot they imagined in their home. Participants were told to keep the blue sheet in front of them and refer to their description and drawing of the robot when answering questions in the questionnaire. The initial questions that were printed on the blue sheet are available in Appendix B.

Questionnaire

The questionnaire consisted of four sections: 1) Views about Robots, 2) Robot Tasks, 3) Technology/Robot Experience, and 4) Demographics and Health. Each section is described in more detail below. The full questionnaire is presented in Appendix C.

Section I: Views about Robots. The purpose of the first section of the questionnaire was to investigate the characteristics of the robot that participants were asked to imagine in their home and the relationship of these characteristics to attitudinal and intention acceptance of the robot. The section was divided into four parts: A) Robot Characteristics, B) Robot Roles, C) TAM Variables, and D) Attitudinal and Intentional Acceptance.

Part A, of Section I, contained 48 variables of robot characteristics as Likert-type items. This strategy was influenced by the method used by Scopelliti, Giuliani, and Fornara (2005) in examining emotional responses to robots, however a much more systematic and comprehensive approach to deriving the variables was taken. The items were created by conducting an extensive literature review of variables found to predict acceptance of technology/machines, social partners, and teammates. The variables identified as predicting use of technology/machines were items such as perceived reliability (Riley, 1996); variables that predicted non-acceptance or disuse of technology/machines included items such as perceived riskiness (Ram & Sheth, 1989). The variables identified from the literature predicting attraction to others as social partners (within the realm of social intelligence), included variables such as expressiveness (Kihlstrom & Cantor, 2000); variables identified as predicting disinterest in another as a social partner included variables such lack of compassion (Dweck & Leggett, 1988). The variables identified as predicting acceptance of others as teammates included variables such as cooperativeness (Eby & Dobbins, 1997); variables identified as predicting low acceptance of others as teammates included variables such as dominance (Stewart, Fulmer, & Barrick, 2005).

From the literature review a list of 80 variables were identified. These variables were narrowed down to equally represent the categories of technology/machine, social partner, and teammate acceptance related variables and to have equal numbers of positive and negative influences on acceptance in their respective domains. Usability testing for word clarity further reduced the number of items. Variables associated with positive and negative influences on acceptance were matched and, within those matches, items with the same root word (e.g., friendly, unfriendly) were altered to avoid biasing participants' answers. Table 1 presents the 48 variables that were selected for inclusion in the questionnaire. As shown in the table, the variables were categorized as relating to social partner, teammate, and technology/machine acceptance, and matched on positive/negative connotations.

The instructions for Part A were for participants to refer to the robot they had described and drawn on the blue sheet and then indicate how much each of 48 words (i.e., robot characteristic variables) matched the characteristics of the robot they had imagined in their home. A Likert-type scale was used from 1 = "not at all" to 5 = "to a great extent"; a "don't know" option was provided to allow for a distinction between a neutral response and a no-opinion response by participants (for a discussion about the benefits of adding such an option see Faulkenberry & Mason, 1978 and Ostini & Nering, 2006). The variables were presented in alphabetized order.

Part B, of Section I, was designed to investigate the match between the robot characteristics in Part A and overall robot role descriptions. Participants were presented with nine robot role descriptions: appliance, assistant, friend, human, machine, pet, servant, teammate, and toy. The roles were selected from various speculative discussions about what functions robots could perform in the future (e.g., Dautenhahn, 2004; Fong, Nourbakhsh, & Dautenhahn, 2003; Roy et al, 2000). The roles selected for inclusion in the questionnaire captured different levels of expected interaction with humans (e.g., high level of interaction as friend and low level of interaction as machine) and different levels of functionality (e.g., high level of functionality as assistant and low level of functionality as toy).

The instructions for Part B were for participants to refer to the robot they had described and drawn on the blue sheet and then indicate how much each of the nine role descriptions matched how they envisioned the robot in their home would be like. A Likert-type scale was used from 1 = "not at all" to 5 = "to a great extent"; a "don't know" option was also provided.

Part C, of Section I, was an adapted version of the TAM using Davis's (1989) four statements about perceived usefulness (performance, productivity, effectiveness and usefulness) and four statements about perceived ease of use (easy to learn to use, easy to become skilled at, easy to get technology to do what user wants, and overall ease of use) as they relate to robots in the home. The purpose of these questions was to allow the relationship between participants' prototypical robot characteristics and TAM-related variable to be examined.

Table 1. *Variables Presented to Participants Related to Teammate, Technology/Machine, and Social Acceptance*

Low Teammate	**High Teammate**	**Low Technology/ Machine**	**High Technology/ Machine**	**Low Social**	**High Social**
Chaotic	Calm	Breakable	Sturdy	Artificial	Lifelike
Demanding	Helpful	Careless	Precise	Boring	Interesting
Dependent	Independent	Clumsy	Coordinated	Dull	Expressive
Hostile	Agreeable	Complex	Simple	Quiet	Talkative
Lazy	Motivated	Pointless	Useful	Serious	Playful
Nervous	Confident	Risky	Safe	Static	Dynamic
Selfish	Trustworthy	Unpredictable	Reliable	Unfeeling	Compassionate
Unimaginative	Creative	Wasteful	Efficient	Unsocial	Friendly

The instructions for Part C were for participants to refer to the robot they had described and drawn on the blue sheet and then indicate how much they agreed with each of eight statements about the robot they imagined in their home. A Likert scale was used from 1 = "strongly disagree" to 5 = "strongly agree"; a "don't know" option was also provided.

Part D, of Section I, was designed to capture participants' attitudinal and intentional acceptance of the robot they imagined in their home. Participants were instructed to refer to the robot they had described and drawn on the blue sheet. They were instructed to indicate their attitudes about the robot they imagined in their home on three 5-point scales (Bad-Good, Unfavorable-Favorable, and Negative-Positive) and their intention to buy the robot if it were available for sale on three 5-point scales (No Intention-Strong Intention, Unlikely-Likely, and Not Buy It-Buy It). Additionally, participants were asked to indicate how likely they would be to recommend the robot to others on a five-point scale (Not Recommend-Recommend). They were asked to indicate who they would recommend the robot to in an open-response format.

Section II: Robot Tasks. The purpose of the second section of the questionnaire was to investigate the types of tasks that participants would be willing to let robots perform in their home and see whether participants' image of their envisioned robot had changed from their initial description. The section had two parts: A) Tasks and B) Change in Expectations.

For Part A, of Section II, participants were presented with 15 possible tasks that robots could perform in the home. These particular tasks were selected to represent five different categories of activities: 1) entertainment-related tasks (e.g., playing games), 2) everyday service tasks (e.g., housework), 3) education/self-enhancement tasks (e.g., learning a new skill), 4) general home health/self-care tasks (e.g., forming exercise schedule), and 5) emergency assistance tasks (e.g., notifying doctor of medical emergency). These categories of robot tasks were selected to be representative of the types of tasks robots currently perform in the home or may possibly perform in the future.

The tasks varied in terms of the amount of interaction they would require with a user; for example low levels of interaction in the case of a robot chasing away an intruder and high levels of interaction in the case of a robot having a conversation with the user. The tasks also represented different levels of criticality, from low, as in the case of entertainment-related tasks to high, as in the case of emergency assistance- related tasks. Participants were instructed to indicate how willing they would be to let a robot perform each task in their home on a Likert-type scale from 1 = “not at all” to 5 = “to a great extent”; a “don’t know” option was also provided.

Part B, of Section II, was intended to see if the image participants had had in their minds of a home-base robot had changed during the course of answering questions about the robot. Participants were instructed to refer to the blue sheet where they had described and drawn the robot they imagined in their home. They were asked whether the image of a robot in their home had changed from what they initially envisioned. If participants indicated that “yes”, the image of a robot in their home had changed, they were asked to indicate how the image had changed in an open-response format.

Section II: Technology and Robot Experience. The purpose of the third section of the questionnaire was to gather information about participants’ experience with technology and robots and their attitudes toward the importance of technology for everyday tasks. The section had three parts: A) Technology Experience, B) Robot Experience, and C) Importance of Technology; additional questions about trusting robots was included at the end of this section.

Part A, of Section III, consisted of 20 items asking participants about their experience with technology over the past year. The items were selected to be representative of technologies that are used in various activities (e.g., work, communication, and home domains); to include both technologies in extensive use (e.g., microwave) and in more limited use (e.g., personal digital assistant); and both “older” technologies (e.g., washing machine) and “newer” technologies (e.g., MP3 player/iPod). Participants were instructed to indicate how often they had used each technology in the past year on a Likert-type scale from 1 = “not at all” to 5 = “to a great extent (several times a week)”; a “don’t know what this is” category was included for participants to indicate if they were not familiar with the technology. The purpose of this part of the questionnaire was to understand the extent of participants’ experience with various types of technology.

Part B, of Section III, consisted of six items asking participants about their experience with categories of available consumer robots (e.g., robot vacuum cleaner). Participants were instructed to indicate their level of experience with each robot category on a Likert-type scale from 1 = “no experience with this robot” to 5 = “I have and use this robot”; an “I’m not sure” category was also included. Participants were given the option of writing more robots in an “other” category and indicating their experience with those robots. The purpose of this part of the questionnaire was to get information about the extent of participants’ experience with available consumer robots.

Part C, of Section III, was intended to ascertain participants’ attitudes about the importance of technology across eight everyday activities: communication, financial, health care, home, learning/education/self-help, leisure/hobby/entertainment, shopping, and work activities. Participants were instructed to indicate how important they felt technology was to the performance of each category of activities on a Likert-type scale from 1 = “not at all important” to 5 = “of vital importance”; an option of “don’t know” was also included.

The last set of questions in Section III was centered on a scenario:

> Imagine that something happened to you (e.g., broke a bone, got sick, lost your memory). If you had to choose between being moved to a care facility (e.g., nursing home, assisted living facility, rehabilitation facility) or remaining in your home and having to use a robot to assist you, which would you choose?

This scenario was presented at the end of this section so as not to influence participants’ answers on previous sections but to make use of participants’ developed mental model of robots. This scenario was included because older adults may be concerned about losing their independence but may be willing to have technology in their home if it allows them to continue living independently (Caine, Fisk, & Rogers, 2007). The phrasing of the scenario was written in a way that it could also be applicable to younger adults.

The options presented for the scenario question were to 1) remain living in home and use a robot, 2) move to a care facility and not use a robot, and 3) don’t know. The subsequent question was: “Would you trust a robot to take care of you in this situation?” Participants were instructed to circle a number on a scale from 1 = “not trust” to 5 = “trust”. Participants were then asked to write what would influence their decision to trust a robot to take care of them in this scenario. The purpose of the scenario and follow-up questions was to ascertain the cost/benefit decision of participants in selecting to use a robot over losing independence.

Section IV: Demographics and Health. The purpose of the fourth section of the questionnaire was to obtain demographic and health information about participants; to not only be able to describe the sample but also to be able to examine relationships between participant characteristics and tasks they would want robots to perform in their home. There were ten demographic questions asking participants about their gender, age, education, race/ethnicity, type of housing, whether they lived by themselves or with others, occupational status, primary occupation, and income. The health portion of the questionnaire had six questions asking participants about their general health, general limits as a result of health, activity limitations due to health, medical conditions, frequency of taking prescription medication, and number of current prescription medications taken.

Summary of questionnaire organization. The following shows the organization of the sections in the questionnaire as well as their respective parts:

- Section I: Views about Robots
    - Part A: Robot Characteristics
    - Part B: Robot Roles
    - Part C: TAM Variables
    - Part D: Attitudinal and Intentional Acceptance
- Section II: Robot Tasks
    - Part A: Tasks
    - Part B: Change in Expectations
- Section III: Technology/Robot Experience
    - Part A: Technology Experience
    - Part B: Robot Experience
    - Part C: Importance of Technology
    - Robot trust scenario questions
- Section IV: Demographics and Health
    - Demographics
    - Health

Sweepstakes

To increase the response rate a sweepstakes was created. Recipients of the questionnaire could enter a sweepstakes to win one of fifty $50 checks. To enter the sweepstakes, individuals were required to send in a sweepstakes entry form. Completion of the questionnaire was not required to enter the sweepstakes.

Mailing and Return Procedures

The questionnaires and supporting materials were printed and mailed by a survey research center. Recipients of the questionnaire were given four weeks to answer and return the questionnaire. They were mailed a reminder postcard two weeks after the initial mailing. Late questionnaire were accepted for three weeks after the due date.

CHAPTER 3: QUESTIONNAIRE ANALYSIS, RESULTS, AND DISCUSSION

The data from returned and completed questionnaires were recorded and analyzed. Statistical tests were conducted through the statistics program SPSS 16.0. All tests were performed at the two-tailed $p = .05$ level, unless otherwise noted.

Respondent Characteristics

Response Rate

Out of a total of 5000 mailed questionnaire packets, 310 packets were mailed back by respondents. Forty-three additional packets were returned to the survey research center as undeliverable. Of returned packets, 200 questionnaires were answered and the remaining packets contained only sweepstakes entry forms. The age of questionnaire respondents were examined for individuals not within the desired age groups. Four respondents were found to be under the age of 18 and 16 respondents were between the ages of 29-64; these questionnaires were removed from further analysis. One questionnaire was answered by an individual 86 years old. This questionnaire was retained and included in the older adult age range. Additionally, eight respondents did not indicate their age. Five of these respondents indicated being retired. Since 100% of the respondents who had indicated being retired and had provided their ages were 65 or older, these five respondents were included within the older adult age group. The three remaining questionnaires without age information were retained, since the questionnaires had been sent to age-targeted lists, but were not placed in an age category. Thus, a total of 180 completed questionnaires were retained for analysis. The overall return rate was 3.6%. Accounting for an age-targeted hit rate of 65%, the response rate was approximately 5.5% of questionnaire recipients who were within the appropriate age categories.

Demographic Information

Out of 180 questionnaires that were included in analysis, 60 were completed by younger adults (aged 18-28), 117 by older adults (aged 65-86), and three by individuals of an unknown age. The demographic information of respondents is presented in Table 2. Chi-square analyses indicated that early (first 90 participants) and late (last 90 participants) respondents were not statistically different in terms of age, $\chi^2(1, N= 176) = .91$, $p = .43$, or gender, $\chi^2(1, N= 176) = 1.88$, $p = .22$.

Several demographic characteristics of the respondent sample should be noted, particularly those concerning difference in the younger and old adult age groups. In terms of gender, the majority of younger adults who responded to the questionnaire were female whereas there was a more equal representation of males and females in the older adult age group.

Participants of both age groups were highly educated, with over 78% of respondents reporting at least some college education. Comparatively, 64% of adults over 25 in the Atlanta area are estimated to have an equivalent level of education (U.S. Census Bureau, 2007). A linear-by-linear chi-square test indicated that older adult respondents tended to report more education than young adult respondents, $\chi^2(1, N = 164) = 4.40$, $p =$ .036. Somers' d indicated a weak, but significant, positive ordinal relationship between age and education, Somers' d = .17, $p = .006$.

In terms of race, the majority of respondents indicated being White/Caucasian, with Black/African American being the largest non-White/Caucasian group represented; there was little representation from other racial groups.

Almost all participants indicated living independently either in a house, apartment, or condominium. Older adults living in assisted living facilities or nursing homes were not represented in the sample of respondents. Older adults, however, were much more likely that younger adults to indicate they lived by themselves, $\chi^2(1, N = 175) = 9.81$, $p = .001$.

With respect to work status, the majority of younger adult respondents indicated working full-time or being students, whereas the majority of older adults indicated being retired. There was a significant positive relationship between age and income, as indicated by a linear-by-linear chi-square analysis, $\chi^2(1, N = 149) = 8.94$, $p = .003$. Somers' d analysis indicated a moderate relationship between age and income, Somers' d = .23, $p = .002$.

The demographics of the questionnaire recipients that did not return the questionnaire are unknown.

Table 2. *Demographic Characteristics of Questionnaire Respondents*

Age Group	***Younger Adult n = 60***	***Older Adults n = 117***	***Total[1] n = 180***
Age Range (*Mean, Std. Dev.*)	18-28 (*22.66, 3.16*)	65-86 (72.23, 5.66)	18-86 (54.93, 24.21)
Gender			
%Male	21.7	53.0	41.7
Highest Level of Education			
%Less than high school	5.0	.8	2.2
%High school/GED	13.8	17.1	16.1
%Vocational training	1.7	2.6	2.2
%Some college/Associate's	46.7	22.2	30.0
%Bachelor's degree	26.7	24.8	25.6
%Master's degree/post-grad	3.3	20.5	14.4
%Doctoral degree	0	2.6	1.7
% Hispanic/Latino	3.3	1.7	2.2
Race			
%Asian	3.3	0	1.1
%Black/African American	11.7	7.7	8.9
%Hispanic/Belizean	1.7	0	.6
%Indian	0	.9	.6
%Latin	0	.9	.6
%Multiracial	1.7	1.7	1.7
%White/Caucasian	81.7	86.3	84.5

[1]Percentages may not add up to 100% due to missing data

Table 2 (continued)

Age Group	***Younger Adult*** ***n = 60***	***Older Adults*** ***n = 117***	***Total*** ***n = 180***
Housing Type			
%Residence hall/dorm	5	.9	2.2
%House/apartment/condo	80.0	93.2	88.3
%Independent senior housing	0	1.7	1.1
%Relative's home	11.7	0	3.9
Household members			
%Living Alone	10.0	30.8	23.3
Mean num. additional members, SD	*2.83, 1.35*	*1.45, .91*	*2.0, 1.28*
Occupational Status			
%Work full time	33.4	12.9	19.9
%Work part time	6.6	6.8	6.7
%Student	43.3	0	14.4
%Homemaker	5.0	2.6	3.3
%Retired	0	65.9	42.8
%Volunteer work	0	2.6	1.7
%Seeking employment	10.0	0	3.3
Yearly Income			
%Less than $25,000	33.3	10.2	17.8
%$25,000-$49,999	18.3	35.0	28.9
%$50,000-$74,999	13.3	20.5	18.3
%75,000-$99,999	8.3	12.0	11.1
%$100,000 or more	3.3	10.2	8.3

Health

Participants were asked questions about their general health, their limits in everyday activities due to health problems, their previous and existing medical conditions, and about their use of prescription medications. A Bonferroni correction at the .008 level was used for all one-way ANOVAs in the following sections.

General health. Participants were asked to indicate their general health on a scale from 1 = "poor" to 5 = "excellent". The means and standard deviations of the responses of younger and older adults are presented in Table 3. The mean of both younger and older adults' responses to this question were between the "good" and "very good" categories. A one-way ANOVA, with age as the grouping variable, revealed no significant difference in reported general health between younger adults and older adults, $F(1, 171) = 1.67$, $p = .198$, $\eta_p^2 = .01$.

Effects of health on performance of everyday activities. Participants were asked to indicate how often their health stood in the way of doing the things they wanted to do on a scale from 1 = "never" to 5 = "always". The mean of younger adults' responses to this question was between the "never" and "seldom" categories, whereas the mean of older adults' responses was between "seldom" and "sometimes". The means and standard deviations of the responses of younger and older adults are presented in Table 3. A one-way ANOVA, with age as the grouping variable, revealed a significant difference in how younger and older adults reported the impact of their health on activities they wanted to do, $F(1, 172) = 10.7$, $p = .001$, $\eta_p^2 = .06$, with older adults reporting more of an impact.

Participants were presented with six categories of everyday physical activities (bathing/dressing, bending/kneeling/stooping, climbing a flight of stairs, lifting bag of groceries, moderate household activities, and vigorous activities) and asked to indicate how much their health limited those activities on a scale from 1 = “not limited at all” to 3 = “limited a lot”. Linear-by-linear chi-square analyses were performed on the six activity categories. Older adults reported significantly more limits in activities due to health for bending/kneeling/stooping, climbing a flight of stairs, moderate household activities, and vigorous activities than did younger adults. The chi-square statistics and Somers’ d measure of ordinal associations, with age group as the independent variable, are presented in Table 4.

A correlation matrix for the six activity categories is available in Appendix D. All correlations were significant at the .01 level (two-tailed) using Spearman’s technique, indicating moderate correlations between limitations across all activity categories. Participants’ responses were summed across the six activities categories, excluding participants with missing scores. Pearson’s correlation was performed between this overall impact of health score, reported general health (Question 1 of health section), and reported frequency of health standing in the way of participants doing what they wanted to do (Question 2 of health section). The sum of impact of health on activities across six categories was significantly negatively correlated to reported general health, $r(170) = -.39$, $p < .001$, indicated a weak negative relationship between limits in activities and perceptions of general health. The sum of impact of health on activities across six categories was significantly positively correlated to frequency of health limiting participants’ ability to do what they wanted to do $r(171) = .55$, $p < .001$.

Medical conditions. Participants were presented with seven medical conditions (arthritis, diabetes, heart disease, hearing impairment, vision impairment, stroke, and cancer) and asked to indicate if they currently had the conditions, ever had the condition in the past, or never had the condition. The frequencies of each response category for younger and older adults, chi-square statistic, and significance of age differences are presented in Table 5. Older adults indicated significantly more instances of arthritis, diabetes, heart disease, hearing impairments, and cancer than younger adults.

Due to a small number of responses indicating medical conditions in the past, compared to responses in the other two categories, responses in this category were combined with the category of currently having the medical condition. Participants were given a score of 1 for each medical condition if they indicated never having the condition and a score of 2 for each medical condition if they indicated ever having the condition. A sum of medical conditions was assigned to each participant, excluding those with missing data for any one or more conditions.

Table 3. *Reported Health of Questionnaire Respondents*

	Group	n	Mean	Std. Dev
Self-reported general health	Younger adults	59	3.71	.79
(1 = poor to 5 = excellent)	Older Adults	114	3.54	.88
	Combined	173	3.60	.86
"How often do health problems stand in the way of doing the things you want to do?"	Younger adults	60	1.75**	.73
(1 = never to 5 = always)	Older Adults	114	2.21**	.95
	Combined	174	2.05	.91

** significant age differences at .01 level

Table 4. *Reported Limits in Activities Due to Health of Questionnaire Respondents*

Activity	Group	n: Not Limited at All	Limited a Little	Limited a Lot	Linear-by-Linear χ^2	*p*	Somers' d[1]
Bathing/ dressing	Younger adults	58	0	2	(1, *N* = 173) = 1.01	.314	-
	Older adults	110	3	0			
	Combined	168	3	2			
Bending/ kneeling/ stooping	Younger adults	52	6	1	(1, *N* = 172) = 11.4	.001**	.257
	Older adults	71	32	10			
	Combined	123	38	12			
Climbing flight of stairs	Younger adults	55	2	2	(1, *N* = 173) = 4.11	.043*	.154
	Older adults	88	23	3			
	Combined	143	25	5			
Lifting bag of groceries	Younger adults	54	5	1	(1, *N* = 172) = 3.14	.077	-
	Older adults	88	20	4			
	Combined	142	25	5			
Moderate household activities	Younger adults	56	2	2	(1, *N* = 173) = 6.47	.011*	.186
	Older adults	84	22	7			
	Combined	140	24	9			
Vigorous activities	Younger adults	45	11	3	(1, *N* = 173) = 32.0	<.001**	.500
	Older adults	34	46	34			
	Combined	79	57	37			

* significant age differences at .05 level

** significant age differences at .01 level

Table 5. *Reported Medical Conditions of Questionnaire Respondents*

			n			
Medical conditions	**Group**	**Never**	**Now**	**In Lifetime**	**Pearson χ^2**	***p***
Arthritis	Younger adults	57	2	1	(2, *N* = 173) =	<.001**
	Older adults	53	52	8	39.3	
	Combined	110	54	9		
Diabetes	Younger adults	57	1	1	(2, *N* = 173) =	.033*
	Older adults	97	16	1	6.83	
	Combined	154	17	2		
Heart disease	Younger adults	59	0	0	(2, *N* = 175) =	<.001**
	Older adults	87	25	4	17.7	
	Combined	146	25	4		
Hearing impairment	Younger adults	57	1	1	(2, *N* = 173) =	<.001**
	Older adults	75	38	1	22.3	
	Combined	132	39	2		
Vision impairment	Younger adults	55	3	1	(2, *N* = 174) =	.095
	Older adults	97	14	0	6.36	
	Combined	152	17	1		
Stroke	Younger adults	58	0	0	(2, *N* = 170) =	.052
	Older adults	105	0	7	3.78	
	Combined	163	0	7		
Cancer	Younger adults	59	1	0	(2, N = 174) =	.001**
	Older adults	88	9	17	13.7	
	Combined	147	10	17		

[*] significant age differences at .05 level
[**] significant age differences at .01 level

Prescription medication. Participants were asked to indicate how often they take prescription medications on a scale from 1 = "never" to 5 = "always (everyday)". A total of 176 participants, 60 younger adults and 116 older adults, responded to this question. The mean of younger adults ($M = 2.77$, $SD = 1.19$) fell between the categories of taking prescription medication a few times per year to at least once a month. The mean of older adults ($M = 4.46$, $SD = 1.19$) fell between the categories of taking prescription medications at least once a week to everyday. A one-way ANOVA, with age as the grouping variable, showed older adults taking prescription medication significantly more frequently than younger adults, $F(1, 174) = 63.1$, $p < .001$, $\eta_p^2 = .27$.

Participants were also asked to indicate how many prescription medications they take on a typical day. An ANOVA showed older adults ($M = 3.03$, $SD = .21$) taking significantly more prescription medications on a typical day than younger adults ($M = .84$, $SD = .30$), $F(1, 164) = 35.5$, p < .001, $\eta_p^2 = .18$. In general, older adults were found to take more prescription medications than younger adults, and take them more frequently.

Overall health-complexity score. An internal consistency reliability assessment was performed on participants' responses to the health section of the questionnaire to investigate the feasibility of summing responses into an overall health-complexity score. Participants' responses to the question about general health were reverse-scored, since this was the only question in which a greater number indicated more positive responses. The assessment was performed on 145 participants without missing data. Cronbach's alpha reliability for the health complexity score based on standardized items was modest but acceptable ($\alpha = .787$) to proceed with a scale of health-complexity. Any item removed from the scale would result in a lower alpha. An inter-item correlation matrix of the six items of the scale is presented in Appendix E.

On the final health-complexity scale the minimum score possible was 16, indicating self-described excellent general health, no limits in activities due to health, no medical conditions, and no prescription medications. There was no imposed limit on maximum score, since the number of prescription medications taken on a typical day was an open-ended question. Those individuals with health-complexity scores above 40 generally indicated poor overall health, several limits in activities due to health, current or previous medical conditions, and frequent use of prescription medications. The mean score on the overall health-complexity scale was 26.5 ($SD = 6.45$). An ANOVA, with age category (young, old) as the independent variable and the health-complexity score as the dependent variable, was performed. Older adults ($M = 29.0$, $SD = 6.10$) had significantly greater health-complexity scores than younger adults ($M = 21.7$, $SD = 3.94$), $F(1,141) = 55.3$, $p < .001$, $\eta_p^2 = .282$.

Technology and Robot Experience

Section III of the questionnaire was used to gather information about respondents' experience with technology and robots, as well as their attitudes about the importance of technology for everyday activities. This information was collected to investigate the relationship between participants' experience with technology and their expectations about robots in their home.

Technology Experience

Participants were asked to indicate how often they had used each of 20 technologies on a scale from 1 = "not at all" to 5 = "to a great extent (several times a week)". A response of "don't know" was counted as a missing value. The mean and standard deviation of responses for younger and older adults across each technology is available in Table 6. For younger adults, the five most frequently used technologies were, in descending order: personal computer/laptop, cell phone, internet/e-mail, CD/DVD, and microwave oven. For older adults they were: telephone, microwave, answering machine, credit card/debit card, and washing machine. The five technologies reported as being used least by younger adults were, in ascending order: home medical device, non-digital camera, personal digital assistant (PDA), in-car navigation system, and cruise control. For older adults they were: PDA, mp3/iPod, in-car navigation system, non-digital camera, and home medical device.

The internal consistency reliability of a proposed technology experience scale was measured using Cronbach's alpha on 153 valid cases. A moderate alpha (α = .790) was observed. However, inter-item correlations between the 20 technologies, which are presented in Appendix F, revealed that two items, home medical device and non-digital camera, were not significantly correlated to any of the other items. Corrected item-total scale correlations of the home medical device and non-digital camera were also low, $r(153) = .051$ and $r(153) = -.015$, respectively. The two items were removed from the scale and Cronbach's alpha analysis was rerun. The resulting alpha (α = .816) was deemed acceptable. An examination of the scree plot from a principal components analysis suggested a single component model of technology experience as appropriate.

Each participant was given a technology experience score based on the mean of their responses to the 18 items on the scale. For this scale, a score of 1.0 would indicate no experience and a score of 5.0 would indicate daily experience with the 18 technological items in the scale. The mean score on the scale was 3.61 (SD = .671). A two-way ANOVA (age x gender) with technology experience as the dependent variable was performed. Younger adults (N = 60, M = 4.05, SD = .441) were found to have significantly more experience with technology than older adults (N = 115, M = 3.38, SD = .664), $F(1, 171) = 35.7$, $p < .001$, $\eta_p^2 = .17$. Female respondents (N = 100, M = 3.65, SD = .714) did not significantly differ in their technology experience than males respondents (N = 75, M = 3.54, SD = .625), $F(1,171) = .079$, $p = .779$. An Age x Gender interaction was also not significant, $F(1, 171) = 1.84$, $p = .176$. Thus age, but not gender, was found to be related to technology experience, with older adults reporting less technology use then younger adults.

Table 6. *Technology Experience: Mean and Standard Deviation of Frequency of Technology Use in the Past Year*[1]

	Group					
	Younger Adults (n = 57)		Older Adults (n = 93)		Combined (n = 150)	
Technology	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Answering machine	3.96**	1.51	4.62**	0.97	4.37	1.24
Automatic teller machine	4.05**	1.03	2.81**	1.68	3.28	1.59
CD/DVD	4.88**	0.33	4.05**	1.23	4.37	1.06
Cell phone	4.91**	0.43	4.34**	1.24	4.56	1.05
Computer game/video game	4.35**	1.17	3.01**	1.81	3.52	1.72
Credit card/debit card	4.68	0.85	4.46	0.92	4.55	0.89
Cruise control	2.96	1.35	3.12	1.58	3.06	1.49
Digital photography	4.32**	1.02	2.80**	1.65	3.37	1.62
Fitness device	3.12*	1.38	2.57*	1.68	2.78	1.59
Home medical device	1.79	1.26	2.29	1.70	2.11	1.56
In-car navigation system	2.20	1.42	1.97	1.54	2.05	1.49
In-store automatic kiosk	3.77**	1.10	2.94**	1.37	3.25	1.34
Internet/e-mail	4.90**	0.56	4.08**	1.62	4.39	1.38
Microwave oven	4.73	0.70	4.82	0.74	4.78	0.72
Mp3/iPod	4.00**	1.55	1.45**	1.15	2.40	1.79
Non-digital camera	1.92	1.16	1.99	1.26	1.97	1.22
Personal computer/laptop	4.95**	0.29	3.65**	1.83	4.14	1.58
Personal digital assistant (PDA)	2.03**	1.51	1.34**	1.13	1.60	1.32
Telephone	4.35**	1.15	4.92**	0.47	4.69	0.85
Washing machine	4.63	0.75	4.39	1.15	4.48	1.02

[1]Scale: 1 = not at all to 5 = to a great extent: several times a week; * significant age differences at .05 level; ** significant age differences at .01 level

Robot Experience

Participants' experience with robots was gauged by asking them to indicate their familiarity with six types of robots on a scale from 1 = "no experience with this robot" to 5 = "I have and use this robot". The means and standard deviations of participants' answers are available in Table 7. An answer of "I'm not sure" was counted as missing data. Overall, participants indicated minimal experience with the six robot types presented. No mean scores indicated extensive first-hand experience with a particular robot type.

The internal consistency reliability of a proposed robot experience scale was measured using Cronbach's alpha on 170 valid cases. With a moderate alpha ($\alpha = .787$) and highly inter-correlated items, a robot experience scale was deemed acceptable. An examination of the scree plot from a principal components analysis suggested a single-component model as appropriate. Correlations between the six items are available in Appendix G. Each participant received a mean score on the robot experience scale. The scale was tested for skewness ($Z_{skewness} = .504$) and kurtosis ($Z_{kurtosis} = .017$); despite a positive skew towards less experience with robots, non-normality did not appear to be of concern.

For the robot experience scale, a score of 1.0 would indicate no experience and a score of 5.0 would indicate extensive experience with (i.e., ownership and use of) the six robot items in the scale. The mean score on the scale was 1.92 ($SD = .735$). A two-way ANOVA (age x gender) was performed on participants' robot experience scores. Younger adults ($M = 2.20$, $SD = .729$) had significantly more reported robot experience than older adults (*M* = 1.77, *SD* = .711), $F(1,171) = 13.6$, $p < .001$, $\eta_p^2 = .07$. Female participants (*M* = 1.86, *SD* = .711) did not significantly differ in their reported robot experience than male participants (*M* = 1.99, *SD* = .785), $F(1,171) = 3.15$, $p = .078$. There was also no significant Age x Gender interaction, $F(1, 171)$, $p = .375$. Thus, like technology experience, age but not gender was found to be a predictor of reported robot experience.

A correlation was performed between robot experience and technology experience. A significant positive correlation, $r(180) = .389$, $p < .001$, was found between scores on these two scales. This indicated a moderate relationship between experience with robots and experience with other types of technology.

Table 7. *Reported Familiarity with Robots*[1]

Robot	Group	Mean	Std. Dev.
Robot factory machine	Younger adults(n =56)	2.36	1.02
	Older adults (n = 111)	2.05	1.08
	Combined (n = 167)	2.16	1.06
Robot lawn mower	Younger adults	1.84	1.11
	Older adults	1.74	0.90
	Combined	1.77	0.97
Robot mopping device	Younger adults	1.95**	1.10
	Older adults	1.49**	0.81
	Combined	1.64	0.94
Robot security guard	Younger adults	1.43	0.87
	Older adults	1.32	0.80
	Combined	1.35	0.82
Robot toy	Younger adults	2.98**	1.36
	Older adults	1.85**	1.09
	Combined	2.23	1.30
Robot vacuum cleaner	Younger adults	2.54**	1.18
	Older adults	2.03**	1.07
	Combined	2.20	1.13

[1]Scale: 1 = no experience with robot to 5 = I have and use this robot; ** significant age differences at .01 level

Attitude towards Importance of Technology for Everyday Activities

Participants were asked to indicate how important they felt technology was to the performance of eight everyday activities on a scale from 1 = “not at all important” to 5 = “of vital importance”. A “don’t know” response was counted as a missing value. The means and standard deviations of the reported importance of the eight activities are presented in Table 8. Overall, participants indicated that technology was at least moderately important across all eight everyday activities.

The feasibility of creating an importance-of-technology scale was evaluated. The internal consistency reliability of the scale, composed of responses to the importance of technology across eight items, was evaluated through Cronbach’s alpha on 151 valid cases. The result alpha ($\alpha = .847$) and high inter-item correlations, presented in Appendix H, suggested the appropriateness of the scale. An examination of the scree plot from a principal components analysis suggested a single component model of technology experience as suitable. Each participant was given a score on the importance-of-technology scale based on the mean of their responses for the eight items in the scale. For this scale, a score of 1.0 would indicate a belief that technology is not at all important and a score of 5.0 would indicate a belief that technology is vital to the performance of the eight everyday activities in the scale. The mean score on the scale was 3.71 ($SD = .782$).

The effect of age and gender on attitudes toward the importance of technology was investigated through a two-way ANOVA (age x gender) on importance-of-technology scale scores. Younger adults ($M = 3.86$, $SD = .77$) did not significantly differ in their attitudes towards the importance of technology for everyday activities from older adults (M = 3.62, SD = .809), F(1, 166) = 1.47, p = .227. Female participants (M = 3.79, SD = .865) did not have significantly different importance-of-technology scores from male participants (M = 3.60, SD = .656), F(1,166) = 1.06, p = .304. So unlike technology and robot experience, age did not appear to be related to attitudes toward the importance of technology for everyday activities; gender did not appear to be related to these attitudes as well.

The correlations between importance-of-technology scores, technology experience, and robot experience were examined. Importance-of-technology scores were found to correlate significantly with technology experience scores, r(175) = .29, $p < .001$, and also with robot experience scores, r(175) = .16, p = .035, although to a lesser degree. This suggested positive relationships among attitudes about technology, technology experience, and robot experience.

Table 8. *Importance of Technology for Everyday Activities*[1]

Activity	Group	Mean	Std. Dev
Communication activities	Younger adults (n = 56)	4.45	0.81
	Older adults (n = 92)	4.49	0.99
	Combined (n = 148)	4.47	0.92
Financial activities	Younger adults	4.14	0.94
	Older adults	3.91	1.02
	Combined	4.00	1.00
Health care activities	Younger adults	4.04	1.16
	Older adults	4.00	1.18
	Combined	4.01	1.17
Home activities	Younger adults	3.57	1.17
	Older adults	3.38	1.18
	Combined	3.45	1.17
Learning/education/self-help activities	Younger adults	3.88	0.97
	Older adults	3.52	1.24
	Combined	3.66	1.16
Leisure/hobby/entertainment activities	Younger adults	3.73*	1.02
	Older adults	3.23*	1.21
	Combined	3.42	1.17
Shopping activities	Younger adults	3.21	1.02
	Older adults	3.02	1.21
	Combined	3.09	1.17
Work activities	Younger adults	4.11**	0.97
	Older adults	3.36**	1.46
	Combined	3.64	1.35

[1]Scale: 1 = not at all important to 5 = of vital importance
* Significant age difference at .05 level
** significant age differences at .01 level

Robot Descriptions and Drawings

The first thing that participants were asked to do for the questionnaire was to imagine that someone gave them a robot for their home. The term "robot' was not defined and purposely left ambiguous. This allowed for participants' concepts of a robot, as free from researcher bias, to be examined. Participants were instructed to take a few minutes to think about what this robot would act like, look like, and do in their home. Participants were then asked to write a description and then draw a picture of their imagined robot on the blue sheet of paper that was separate from the rest of the questionnaire. As participants were told to refer to their descriptions and pictures on this blue sheet when answering Section I of the questionnaire, this initial exercise was an important part of understanding participants' prototypical robot characteristics.

Out of 180 participants, 179 returned the blue sheet with their questionnaire. Seven participants did not fill out the sheet or wrote irrelevant comments on the sheet, and were thus not included in analysis. Eight additional participants provided written descriptions of their robot but no drawing; one participant made two drawings but did not write a description. Blue sheets with at least a written description or a drawing were retained. A total of 172 blue sheets were analyzed. The sample was comprised of 58 younger adult participants and 111 older adult participants.

A coding scheme was developed to analyze participants' robot descriptions and drawings. There were two main goals of the coding scheme: 1) To identify what features of prototypical home-based robots are the most salient to participants and 2) To distinguish between human-like and machine-like robots. Each participant's robot description and/or drawing was coded along 53 dimensions under larger categories of overall appearance, head and facial features, appendages, mobility, interaction features, tasks, control, and other characteristics. The descriptions and drawings were coded together, as information from one could supplement, reinforce, or clarify information in the other. The full coding scheme is available in Appendix I.

Robot drawings and descriptions were coded by a principal coder and two secondary coders. Initially, five descriptions/drawings were randomly selected and coded by all three coders. The inter-rater reliability between the principal coder and co-coders were 89% and 92%. The codings to retain for these five descriptions/drawings were randomly selected. For the remaining robot descriptions/drawings, dimensions 1.1.1, 1.1.2, and 1.1.3 in the coding scheme, corresponding to human-like appearance, machine-like/mechanical appearance, and animal-like appearance, were coded by all three coders. The coding of the description/drawings for the remainder of the coding scheme was done by a single coder. The principle coder was responsible for coding 50% and each secondary coder for 25% of the robot descriptions/drawings.

Overall Appearance

The descriptions and drawings that participants provided of their imagined home-base robots were coded for overall appearance. Appearance included both the overall "Gestalt" of the drawings as well as explicit written information from the robot descriptions.

Human-likeness, machine-likeness, and animal-likeness. All coders gave scores for each description/drawing on the traits of human-like appearance, machine-like/mechanical appearance, and animal-like appearance from 1 = "not at all" to 5 = "explicitly stated". The scores coders gave for each dimension was averaged for each participant. Figure 1 shows images of robots that were given low, medium, and high scores for overall human-like and machine-like/mechanical appearance. The figure also contains an image of the robot rated highest on overall animal-like appearance.

The descriptive statistics for scores of human-like, machine-like/mechanical, and animal appearance are presented in Table 9. Paired t-tests, with a Bonferroni correction at the .0167 level, were used to identify differences in the mean scores on the three overall appearance scales. Participants' robots had mean scores that were significantly greater for machine-like appearance than for human-like appearance, $t(171) = 2.77$, $p = .006$, and significantly greater for machine-like appearance than for animal-like appearance, $t(171) = 18.78$, $p < .001$. Scores for human-like appearance were significantly greater than for animal-like appearance, $t(171) = 9.87$, $p < .001$. Pearson correlations indicated a significant negative correlation between human-like and machine-like appearance scores $r = -.75$, $p <.001$, and between human-like and animal-like appearance scores, $r = -.21$, $p = .006$. The correlation between machine-like and animal-like appearance scores were not significant, $r = .07$, $p = .356$.

A MANOVA was conducted to look at age differences in the overall appearance of participants' imagined robots. Only human-like and machine-like appearance scores were included as dependent measures, because the scores of animal-like appearance were restricted towards the bottom of the scale. Box's M test of the equality of covariance matrices was not significant, *Box's M* = 7.55, $p = .06$. The analysis indicated a significant, although weak, effect of age on overall appearance score, Pillai's Trace statistic $F(2,166) = 8.45$, $p < .001$. Univariate analysis indicated a significant effect of age for human-like appearance scores, $F(1,167) = 10.44$, $p = .001$, $\eta_p^2 = .06$, with younger adults having higher scores than older adults. There was not a significant effect of age on machine-like appearance scores, $F(1,167) = .70$, $p = .404$. Thus, younger adults tended to describe and draw robots that, overall, had more human-like characteristics, but not necessarily less machine-like characteristics than did older adults. The differences in mean human-like appearance scores, but not machine-like appearance scores, between younger and older adults' described and drawn robots can be seen in the graph presented in Figure 2.

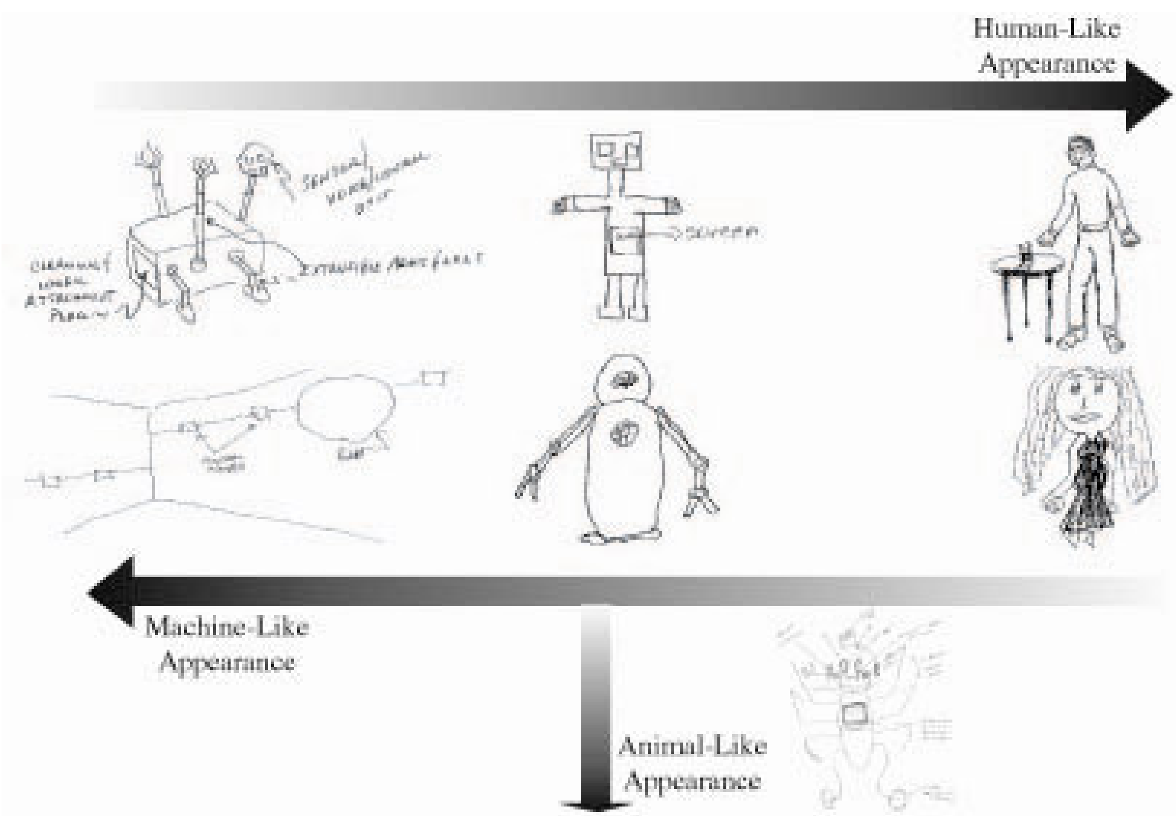

Figure 1. Robot drawings

Table 9. *Descriptive Statistics for the Overall Robot Appearance*

Overall Appearance	**Group**	**Mean**	**Std. Dev.**	**Skewness**	**Kurtosis**
Human-like	Younger adults (n = 58)	2.81**	1.60		
	Older adults (n = 111)	2.07**	1.29		
	Total (n = 172)	2.32	1.44	0.70	-1.02
Machine-like	Younger adults	2.74	1.14		
	Older adults	2.89	1.16		
	Total	2.83	1.14	-0.29	-1.17
Animal-like	Younger adults	1.13	0.26		
	Older adults	1.18	0.34		
	Total	1.17	0.31	2.10	4.35

** significant age differences at .01 level

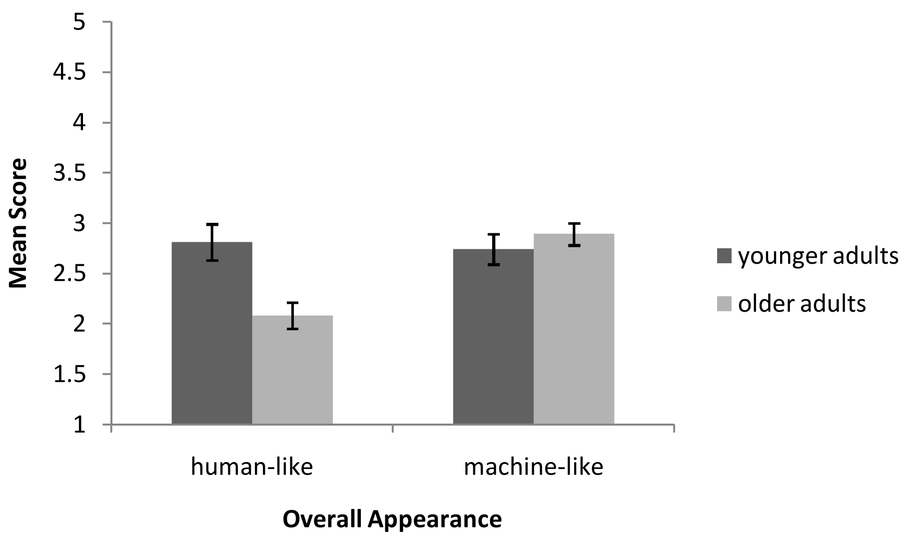

Figure 2. Mean scores of younger and older adults' robot descriptions and drawings on the scales of human-like appearance and machine-like appearance. Bars are standard errors of the mean.

Robot height. Approximately 23% (N = 40) of participants either explicitly (e.g., "approximately 20 inches high") or implicitly (e.g., "much smaller than a human") indicated the height of their imagined robots. In relation to average human height, 28% of participants who indicated height imagined the robot to be much shorter than a human (under 3 ft); 28% imaged the robot to be slightly shorter than an average human (equal to or greater than 3 ft but less than or equal to 5 ft), or approximately the height of a child; 25% described the robot as being of average human adult height. Additionally, 15% of participants who gave indication of their robot's height described the robot as having multiple or adjustable heights. For example the robot was described as changing height depending on the tasks it was asked to perform. Only one participant described the robot as being taller than a human of average height. The sample size of participants who indicated robot height was not large enough to support an analysis of age differences in imagined robot height.

Head and Facial Features. Participants' robot drawings and descriptions were coded for the presence of a head and facial features – indicators of more human-like robots with social characteristics. Over half (58%, N = 100) of participants gave indication that their robot had a head; 40% (N = 68) indicated their robot had a face. The most common facial features participants indicated for their robot were eyes (38%, N = 65), followed by mouth (33%, N = 56), nose (20%, N = 34), and ears (8%, N = 13).

Each participant was given a head-face score from the sum of the number of types of facial features described and/or drawn plus one point for the presence of a head, with a minimum value of 0 (no head or facial features) to a maximum value of 5 (presence of head, eyes, ears, nose, and mouth). The distribution of scores is presented in Figure 3.

There was no clear trend in the number of facial features that participants ascribed to their robot. A linear-by-linear chi-square analysis indicated that the robots that younger adults had described and drawn had significantly more instances of a head and facial features than older adults' robots, $\chi^2(1, N = 169) = 11.91$, $p = .001$. Somers' d statistic of ordinal association was significant, *Somers' d* = -.314, $p < .001$.

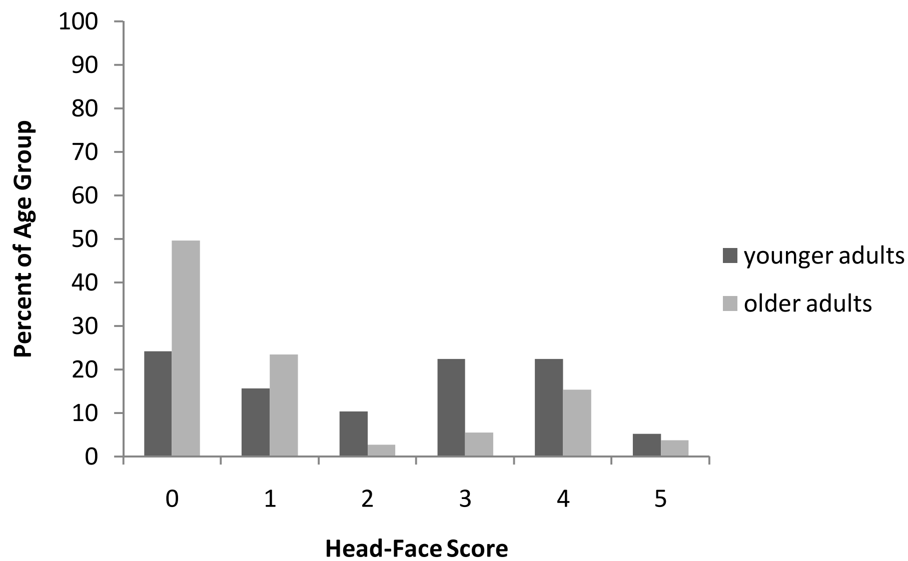

Figure 3. Percent of questionnaire respondents receiving each head-face score for described and/or drawn robots. A score of 0 was given when no head or facial features were ascribed to the robot; a score of 5 was given when the robot had a head and four types of facial features (eyes, ears, nose, and mouth).

Appendages. The number of biological arms and mechanical "arms" that participants gave their robot were recorded. Arms were defined as extensions from the robot's body that appeared to allow the robot to manipulate something in the environment. Biological arms were defined as arms that suggested a living being (e.g., human-like arms), whereas mechanical arms were defined as extensions that suggested machine-like attachments to the body (e.g., vacuum cleaner attachments). Figure 4 shows the distinction between biological and mechanical arms. Robot arms were coded as either biological or mechanical, but not both.

The majority (77%) of participants indicated that their robot had some form of arms, with 42% indicating biological arms and 36% indicating mechanical arms; only one participant described and drew a robot with both biological and mechanical arms. Of the participants who described and/or drew a robot with biological arms, 97% gave their robot two arms; one participant had a robot with four arms and another participant had a robot with six arms. Of the participants who described and/or drew a robot with mechanical arms, the majority (89%) also gave their robot two arms; seven participants had a robot with one arm, two participants with three arms, and one with four arms. A chi-square analysis indicated that younger adults were more likely to describe and/or draw their robot with biological arms than were older adults, χ^2 (1, N = 160) = 4.97, p = .03. Younger adults were no more likely than older adults to describe and/or draw a robot with mechanical arms, χ^2 (1, N = 156) = .268, p = .60.

Mobility. Participants' descriptions and/or drawings of their imagined robot were coded for features that allowed the robot to move around. The majority of participants (89%) either explicitly (e.g., stating the robot is mobile) or implicitly (e.g., drawing the robot with wheels) indicated that their robot was mobile. A chi-square analysis indicated that younger and older adults were equally likely to indicate mobile robots, χ^2 (1, N = 162) = 1.95, p = .16.

Of the participants who indicated their robot was mobile, 55% imagined their robot with legs or feet, with 100% of these participants giving their robot two legs or feet. Less common than robots with legs were robots with wheels (39% of mobile robots) and robots with treads or tracks (5% of mobile robots). Seven participants gave their robot legs and wheels.

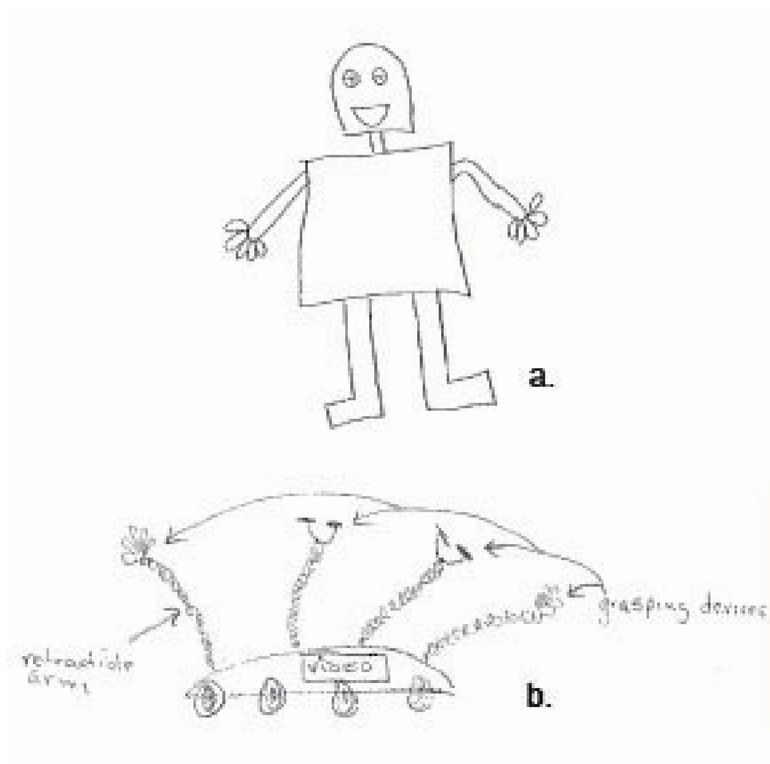

Figure 4. Example drawing of a robot with biological arms (a) and a robot with mechanical arms (b)

Interaction features. The number of robots that participants described and/or drew with interaction features such as buttons and screens were coded. Approximately a quarter (24%) of participants indicated that their robot had one or more interaction features. Of these, 64% described and/or drew robots with buttons and 52% with screens. A chi-square analysis indicated no difference in the likelihood of younger and older adults describing and/or drawing their robot with interaction features, χ^2 (2, N = 169) = 1.64, p = .440.

Tasks. The types of tasks that participants described their imagined robot performing were coded. Most participants (77%) described at least one task that their robot would perform. The frequency of the types of tasks mentioned is presented in Figure 5. As seen in the figure, the most commonly mentioned tasks were cleaning and chore-type tasks. Security activities, physical aiding/assisting, working with other machines, and cooking were tasks that were mentioned to a moderate degree by participants.

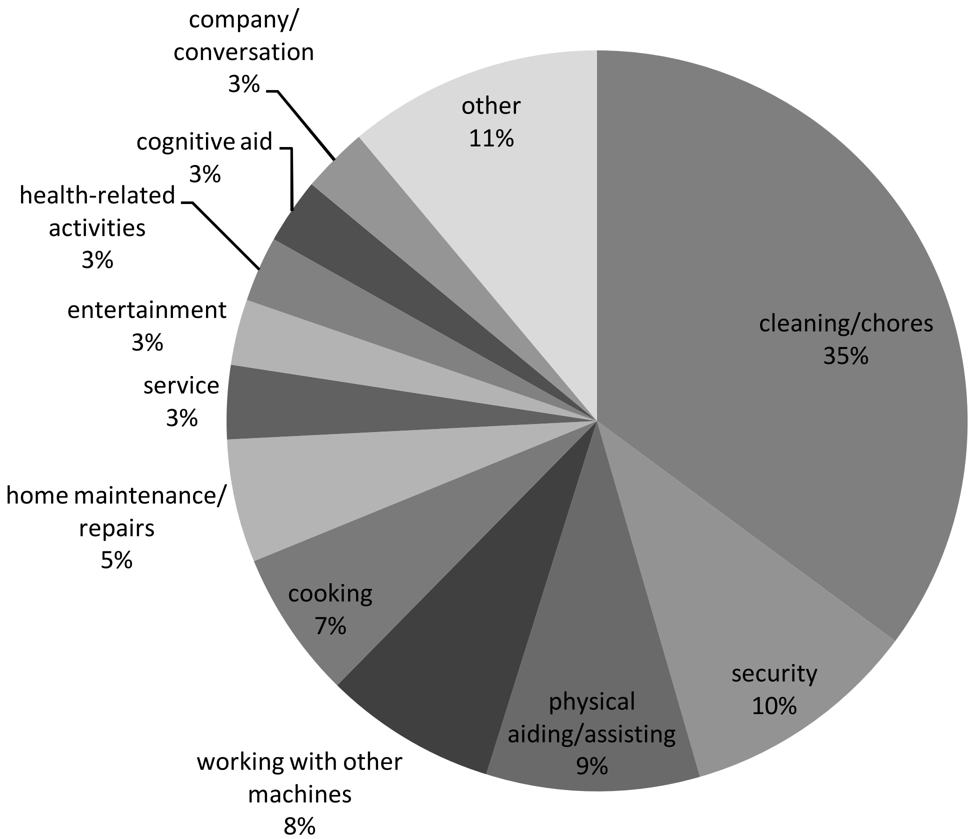

Figure 5. Percent each type of task was mentioned in participants' robot descriptions and drawings out of all task types mentioned.

Control. Participants' robot descriptions and drawings were coded for how the robot is controlled or how the robot knows what to do. About one-fifth (21%) of participants indicated that their imagined robot would be programmed; 33% indicated that they would have a way to directly tell the robot what to do. Of the participants that described direct manipulation of their robot, 54% described their robot as being controlled by voice commands or activation, 23% by input or interfaces on the robot (e.g., touch screens or buttons), 12% by remote control, and 11% by other means of input. Additionally, 14% of participants indicated that their robot had some kind of sensors (e.g., visual sensing systems or voice recognition).

Other Characteristics. Several other characteristics of the robots that participants described and drew were coded. For example, 19% of participants had robots with antennae, 12% gave their robot clothing, and 17% assigned a gender to their robot (9% male, 8% female). Some participants drew additional items with their robot: 5% drew cleaning supplies (e.g., dust pan and broom), 4% drew interchangeable parts, and 4% drew batteries.

Views about Robots

Robot Characteristics

Participants were presented with 48 words and asked to indicate how much those words matched the characteristics of the robot they had imagined in their home on a scale from 1 = "not at all" to 5 = "to a great extent". As a reminder, there were eight words presented from each of six categories: 1) low teammate, 2) high teammate, 3) low technology/machine, 4) high technology/machine, 5) low social, and 6) high social. The list of variables in their respective categories are presented in Table 1. A response of "don't know" was counted as a missing value.

To investigate the underlying factor structure of robot characteristics, the variables were run though a principle axis factor analysis procedure. A principle axis extraction was used due to the procedure not being dependent on distributional assumptions (e.g., insensitivity to violations in multivariate normality; Fabrigar, Wegener, MacCallum, & Strahan, 1999); although Gorsuch (1983) suggested that when the number of variables is moderately large, such as the case in this analysis, extraction methods for exploratory procedures will tend to lead to similar interpretations. The maximum iterations for extraction were set at 100, factor loading with absolute values under .4 were suppressed, and only eigenvalues over 1 were extracted. A promax rotation was used with kappa equal to 4 (as recommended by Gorsuch, 1983).

First, the factorability of the 48 items was investigated. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy value was .745 and Bartlett's test of sphericity was significant, $\chi^2(1128) = 3364.71$, $p < .001$. The diagonals of the anti-image correlation matrix were examined and were found to all be over .4, which supported the retention of all items in the factor analysis. The factorability of items, based on these findings, was considered acceptable (Hutcheson & Sofroniou, 1999).

A total of 11 factors had eigenvalues greater than 1.0. A scree test was used to determine the number of factors to retain (Cattell, 1966). The scree plot showed three major factors followed by a leveling off, "elbow" at the fourth factor. The retention of the fourth factor added minimal explanation of the variance in initial eigenvalues and little interpretive value above that of the three-factor model (Kim & Mueller, 1978). The initial eigenvalues showed that the first factor explained 25% of the variance, the second factor 12% of the variance, and the third factor 8% of the variance. The three factor solution thus explained 45% of the variance in initial eigenvalues.

Seven items (complex, dependent, independent, interesting, pointless, simple, and static) did not meet the criterion of having factor loadings greater or equal to .4 on any of the three major factors. These items were nearly equally representative from the teammate (dependent and independent), technology/machine (complex, pointless, and simple) and the social (static and interesting) categories from which the 48 items were developed. Furthermore, the seven items were nearly equally representative of positive (independent, interesting, and simple) and negative (complex, dependent, pointless and static) traits in these three categories; four of the items (dependent and independent; complex and simple) were matched opposite pairs within their respective categories. Thus, no single category had a larger proportion of items with factor loading less than .4 for each of three major factors extracted through factor analysis. The removal of the seven items from the factor analysis was considered appropriate because they did not contribute to the dominant factor structure and were equally representative from the categories of teammate, technology/machine, and social robot characteristic categories, across both positive and negative traits within these categories.

A principle-axis factor analysis was rerun with these seven items removed, for a total of 41 items included. The three factors extracted from the analysis explained 45% of the variance on the extracted sums of squares loadings. Five iterations were required for the initial three factor extraction and eight iterations for the promax rotation. The factor correlation matrix and structure matrix and for the factor analysis are available in Appendix J. The pattern matrix with regression weights and communalities for this final solution is presented in Table 10. The table also compares regression weights with the original categories of teammate, technology/machine, and social acceptance from which the items in the questionnaire were developed. As seen in Table 10, the first factor was largely composed of items from positive traits in the technology/machine and teammate acceptance categories, the second factor of positive and negative traits in the social acceptance category, and the third category of negative traits in the technology/machine and teammate acceptance categories. The three factors were labeled “performance-oriented traits”, “socially-oriented traits”, and “non-productive traits”, respectively.

Composite scores for each of the three factors were created, based on the mean of the items which loaded onto each factor. First, items with negative loadings (e.g., unfeeling) were reverse scored. Then, each participant received a mean score on each of the three factors. The item “motivation” was the only factor that had loadings greater than .4 on more than one factor. Given that loadings were roughly equal (.43 vs. .46) the item was included in the mean for both the performance-oriented trait and the socially-oriented trait factors. Descriptive statistics for the three factors are presented in Table 11. Correlations between factors are presented in Table 12. The performance- and socially-oriented trait factors were found to be significantly positively correlated. Both of these were significantly negatively correlated with the non-productive factor.

Table 10. *Factor Weights and Communalities Based on a Principle Axis Analysis with Promax Rotation for 41 Items of Robot Characteristics (N=177) and Comparison to Original Variable Categories*

		Factor Weights[1]			Communalities	
Item	**Original item category[2]**	**Performance -oriented traits**	**Socially-oriented traits**	**Non-productive traits**	**Initial**	**Extraction**
Efficient	Tech/machine+	0.81			0.65	0.60
Reliable	Tech/machine +	0.78			0.78	0.67
Precise	Tech/machine +	0.75			0.71	0.57
Helpful	Teammate+	0.75			0.76	0.59
Coordinated	Tech/machine +	0.71			0.78	0.56
Useful	Tech/machine +	0.69			0.79	0.57
Safe	Tech/machine +	0.64			0.69	0.49
Quiet	Social-	0.63			0.56	0.40
Calm	Teammate +	0.62			0.66	0.36
Sturdy	Tech/machine +	0.62			0.59	0.33
Agreeable	Teammate +	0.58			0.58	0.39
Confident	Teammate +	0.54			0.68	0.38
Trustworthy	Teammate +	0.53			0.70	0.48
Serious	Social-	0.48			0.64	0.30
Dynamic	Social +	0.45			0.57	0.36
Unfeeling	Social -		-0.85		0.80	0.59
Compassionate	Social +		0.71		0.83	0.57
Unimaginative	Teammate -		-0.71		0.71	0.42
Unsocial	Social -		-0.70		0.75	0.43
Expressive	Social +		0.69		0.81	0.64
Friendly	Social +		0.63		0.82	0.64
Dull	Social +		-0.63		0.79	0.38
Playful	Teammate +		0.60		0.73	0.57
Creative	Teammate +		0.60		0.75	0.53
Lifelike	Social +		0.57		0.68	0.48
Artificial	Social -		-0.54		0.51	0.26
Boring	Social -		-0.49		0.74	0.26
Motivated	Teammate +	.0.43	0.46		0.71	0.56
Talkative	Social+		0.45		0.63	0.39
Unpredictable	Tech/machine -			0.67	0.69	0.53
Wasteful	Tech/machine -			0.66	0.65	0.51
Chaotic	Teammate -			0.66	0.68	0.54
Risky	Tech/machine -			0.61	0.74	0.49
Demanding	Teammate -			0.58	0.60	0.35
Clumsy	Tech/machine -			0.58	0.66	0.53
Selfish	Teammate -			0.54	0.55	0.30
Nervous	Teammate -			0.52	0.73	0.28
Lazy	Teammate -			0.51	0.67	0.31
Breakable	Tech/machine -			0.47	0.54	0.33
Careless	Tech/machine -			0.46	0.72	0.30
Hostile	Teammate -			0.45	0.69	0.21

[1]Factor weights <.4 are suppressed [2]plus sign denotes positive trait and minus sign denotes negative trait in original trait category

Table 11. *Descriptive Statistics for the Three Robot Characteristic Factors (N = 180)*

Factor	**No. of items**	**Mean**	**Std. Dev.**	**Skewness**	**Kurtosis**	**Cronbach's alpha**
Performance-oriented traits	16	3.85	0.82	-1.15	1.62	.92
Socially-oriented traits	14	2.88	0.97	0.17	-0.99	.91
Non-productive traits	12	1.46	0.57	2.70	11.55	.76

Table 12. *Correlations between the Three Robot Characteristic Factors*

Factor	*1*	*2*	*3*
1. Performance-oriented traits	--	.423**	-.488**
2. Socially-oriented traits		--	-.229 **
3. Non-productive traits			--

** significant at the .01 level (two-tailed)

Before proceeding with a multivariate analysis to examine age differences between the characteristics younger and older adults ascribed to their home-based robot, assumptions of the equality of covariance matrices of the three factors was investigated through Box's M test. The assumption was found to be violated, Box's M = 81.80, $p < .001$. To test if the violation of the assumption of equality of the covariance matrices were due to outliers, Mahalanobis distances for all three factors were calculated. The criterion was set at $\chi^2(3) = 11.35$ at $p < .01$. Five distances were found to exceed this criterion. Furthermore, one participant had extensive missing data across the 48 items. With these outliers removed from analysis, the skewness and kurtosis of the scales were greatly reduced (see Table 13), however Box's M test was still significant, Box's M = 14.32, $p = .03$. The violation of equality of covariance matrices for groups suggested the inappropriateness of a multivariate approach for the data set at the risk of uncontrolled Type I error rates (Coombs & Algina, 1996, Coombs, Algina, & Oltman, 1996).

The value in performing alternative tests, such as modified Brown-Forsythe tests (Coombs & Algina, 1996) or resorting to resampling methods (Garson, 2008b), to investigate age-related differences in robot characteristic means scores was considered. First, the covariance matrices of younger and older adults were examined to understand what factors were contributing to disparity in the matrices. The covariance matrices for each age group across the three robot characteristic variables are presented in Appendix J. The examination of the matrices suggested that the first factor, performance-oriented traits, was largely responsible for the significance of the inequality of the covariance test. A histogram of performance-oriented trait scores suggested that the inequality of variance between younger and older adults for these scores were due to older adults having more extreme (i.e., the highest and the lowest) scores, whereas younger adults had more moderately dispersed scores around the mean.

An ANCOVA was conducted on the performance-oriented trait factor alone with age group (younger, older) as the independent variable and technology experience and robot experience as covariates. Neither age, $F(1, 167) = .133$, $p = .713$, nor robot experience, $F(1,167) = .283$, $p = .596$, were found to have significant effects on performance-oriented trait scores. Technology experience had a significant, although weak, relationship with these scores, $F(1,167) = 7.24$, $p = .008$, $\eta_p^2 = .04$. A t-test assuming unequal variances for age groups indicated a significant difference in performance-oriented trait scores between older and younger adults, $t(171) = 2.29$, $p = .024$.

A MANCOVA was performed on the other two factors, socially-oriented traits and non-productive traits, with age group (younger, older) as the independent variable and robot experience and technology experience as covariates. Box's M test was performed to test the equality of covariance matrices. With only socially-oriented and non-productive trait variables in the multivariate test, Box's M test was non-significant, *Box's M* =.63, $p = .891$. Again, age did not have a significant effect on scores, Pillai's Trace statistic $F(2,166) = 2.48$, $p = .087$. Robot experience, $F(2,166) = .746$, $p = .476$, and technology experience, $F(2,166) = 2.57$, $p = .079$ did not have significant relationships with trait scores.

Because both the ANOVA and MANCOVA analyses indicated non-significant effects of age on scores, it was decided that the value of running alternative tests were minimal–there was sufficient evidence that, with robot and technology experience accounted for, age did not have a significant effect on robot characteristic trait scores.

Paired t-tests, with a Bonferroni correction at the .0167 level, were conducted to look at differences in the means of the three robot characteristics factors with age collapsed. The tests indicated that participants ascribed significantly more performance-oriented traits to their imagined robots than socially-oriented traits, $t(173) = 14.65$, $p < .001$, significantly more performance-oriented traits than non-performance traits, $t(174) = 32.3$, $p < .001$, and significantly more socially-oriented traits than non-performance traits, $t(173) = 16.71$, $p < .001$. Plots of the means for the three robot characteristic factors are presented in Figure 6. As seen in the figure, participants generally attributed positive characteristics to their prototypical home-based robots. They imagined their robot primarily as devices with functional abilities and secondly as devices with social abilities.

Table 13. *Descriptive Statistics for the Three Robot Characteristic Factors with Outliers Removed*

Factor	**Group**	**Mean**	**Std. Dev.**	**Skewness**	**Kurtosis**
Performance-oriented traits	Younger adults (n = 59)	4.08	0.54		
	Older adults (n = 112)	3.84	0.80		
	Total (n = 174)	3.92	0.73	-0.83	0.59
Socially-oriented traits	Younger adults	3.08	0.98		
	Older adults	2.81	0.96		
	Total	2.89	0.98	-.0.01	-0.98
Non-productive traits	Younger adults	1.41	0.44		
	Older adults	1.41	0.44		
	Total	1.41	0.43	1.20	0.81

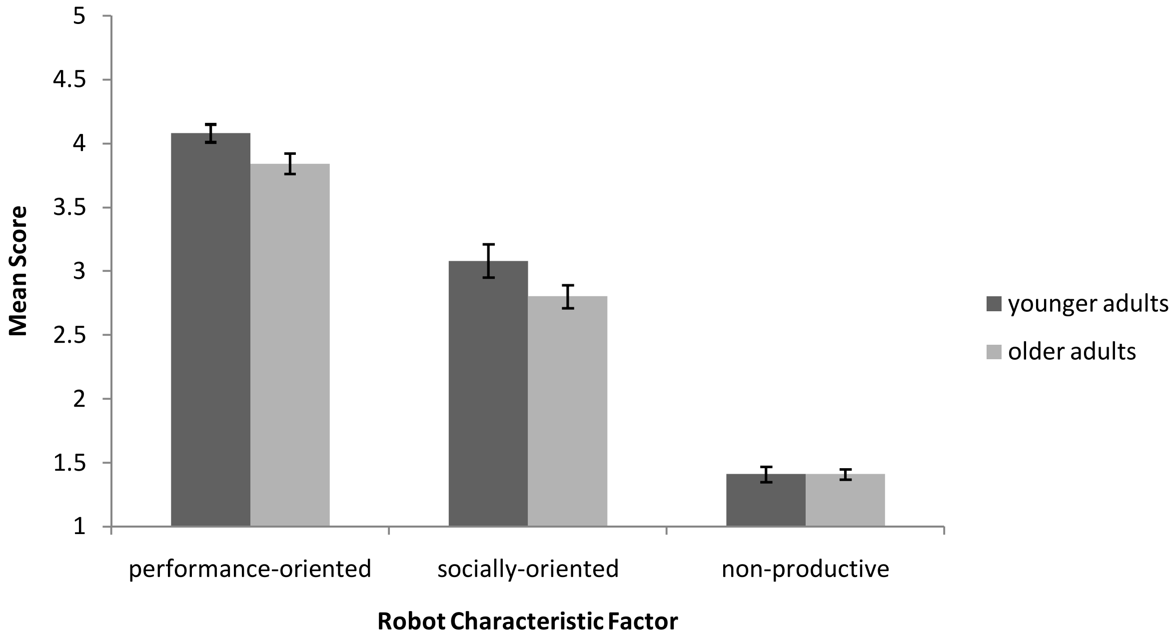

Figure 6. Participants' mean scores on the three robot characteristic factors. Error bars are standard errors of the mean.

Relationships between robot descriptions and drawings and robot characteristic factors. It was predicted that participants' robot characteristic factor scores (performance-oriented, socially-oriented, and non-productive traits) and characteristics of participants' drawn and described robots would be strongly related. More specifically, it was predicted that socially-oriented trait scores would be positively correlated with the human-like appearance scores and head-face scores that participants were given for their initial robot drawings and descriptions; performance-oriented and non-productive trait scores were expected to be correlated to machine-like appearance scores, in the positive and negative directions respectively. The correlations between robot characteristic scores and robot drawing/description scores are presented in Table 14. As expected, the socially-oriented trait scores were positively correlated with human-like appearance scores and head-face scores, but negatively correlated with machine-like robots. Interestingly, there was no correlation between the performance-oriented trait scores and human-like appearance, machine-like appearance, and head-face scores. However, there was a significant correlation between non-productive factor scores and machine-like appearance scores. These correlations suggested that human-like robots are viewed by participants as being more social than machine-like robots.. The prototypical appearance of robots does not appear to be related to how productive participants believe their robot will be, but machine-like robots may be perceived as having more negative traits, such as uncontrollability.

Table 14. *Correlations between Robot Characteristic Scores and Scores from Participants' Robot Drawings and Descriptions*

	Robot drawings and description scores		
Robot characteristic scores	Human-like	Machine-like	Head-face
Performance-oriented	.138	-.143	.072
Socially-oriented	.327**	-.415**	.302**
Non-performance	-.100	.163*	-.034

* significant at the .05 level (two-tailed)
** significant at the .01 level (two-tailed)

Robot Roles

Participants were presented with nine robot roles and asked to indicate how well those roles fit their perceptions about their imagined home-based robot on a scale from 1 = "not at all" to 5 = "to a great extent". As a reminder, the robot roles varied in terms of the amount of interaction they would have with the user as well as their functionality. A response of "don't know" was counted as a missing value.

To investigate the underlying relationships between the robot roles, the nine role items were run through a principle axis factor analysis with promax rotation at kappa = 4. Factor loading less than .4 were suppressed. The factorability of the nine items was acceptable with a KMO measure of sampling adequacy at .729 and a significant Bartlett's test of sphericity, $\chi^2(36) = 523.51$, $p < .001$.

A three factor solution emerged from the examination of the scree plot. The first factor accounted for 37%, the second factor for 19%, and the third factor for 13% of the variance of the initial eigenvalues, together totaling 69% of the variance. The three factors accounted for 54% of the extracted sum of squares loadings. Thirteen iterations were required for the initial extraction, and six iterations for the convergence of rotation. The pattern matrix with factor weights and communalities for the three factor solution are presented in Table 15. The correlation matrix for all robot role items, structure matrix, and factor correlation matrix are available in Appendix K.

The robot role factors that emerged from the analysis revealed the influence of the status of the robot in relation to the human user. The first factor included roles in which the robot replaces a human or acts like a human, with the opposite end of the scale including roles in which the robot is clearly a machine or appliance. The status of the robot would be considered equal to, or nearly equal to the user. The second factor included roles in which the robot plays more of a supportive role to the user. The status of the robot would be considered below that of a human, but with clear functionality. The third factor included roles in which the robot would be considered subordinate to the user and without clear functionality. The three factors were thus labeled “human role”, “supportive role”, and “subordinate role”.

Table 15. *Factor Weights and Communalities Based on a Principle Axis Analysis with Promax Rotation for Nine Items of Robot Roles (N = 178)*

	Factor Weights[1]			**Communalities**	
Item	**Human role**	**Supportive role**	**Subordinate role**	**Initial**	**Extraction**
Machine	-1.02			0.53	0.79
Appliance	-0.71			0.41	0.39
Friend	0.58			0.71	0.80
Human	0.56			0.62	0.64
Assistant		0.96		0.38	0.62
Servant		0.69		0.31	0.34
Teammate		0.49		0.51	0.50
Toy			0.72	0.20	0.42
Pet			0.50	0.30	0.39

[1]Factor weights <.4 are suppressed

Composite scores for each of the three role factors were created, based on the mean of the items which loaded onto each factor. The items with negative loadings were reverse scored. Each participant received a mean score on each of the three factors. The descriptive statistics for each robot role factor is presented in Table 16 and the correlations between them in Table 17. Perceptions of robots as having human roles were significantly positively correlated with perceptions of robots having supportive roles, but not with subordinate roles. The perception of robots as having supportive roles was correlated to perceptions of robots as having subordinate roles, but the correlation was weaker than the correlation between human roles and supportive roles.

Paired t-tests, with a Bonferroni correction at the .0167 level, were conducted to look at differences in the means of the three robot role factors. The tests indicated that participants thought of robots as being in supportive roles more than in human roles, $t(178) = 8.67$, $p < .001$, in supportive roles more than in subordinate roles, $t(176) = 13.38$, $p < .001$, and in human roles more than in subordinate roles, $t(175) = 4.20$, $p < .001$.

It was hypothesized that participants' perceptions of the overall role of their prototypical robots would be strongly related to the characteristics traits they assigned to their robot. More specifically, that performance-oriented traits would be positively correlated with perceptions of robots in supportive roles, in which functionality of robots is critical; socially-oriented traits would be positively correlated with perceptions of robots in human roles, in which social intelligence is critical; and finally, non-productive traits would be positively correlated with perceptions of robots in subordinate roles, in which the functionality of robots is under-defined. The correlations between the three robot characteristic factors and the three robot role factors are shown in Table 18.

Table 16. *Descriptive Statistics for the Three Robot Role Factors*

Factor	No. of Items	Group	Mean	Std. Dev.	Skewness	Kurtosis	Cronbach's Alpha
Human role	4	Younger adults (n = 59)	2.47	1.22			
		Older adults (n = 112)	2.18	1.19			
		Total (n = 179)	2.27	1.20	0.71	-0.72	0.83
Supportive role	3	Younger adults	3.41	0.95			
		Older adults	2.97	1.13			
		Total	3.11	1.10	-.0.14	-0.71	0.64
Subordinate role	2	Younger adults	2.12	0.98			
		Older adults	1.65	0.82			
		Total	1.80	0.90	1.00	0.62	0.37

Table 17. *Correlations between the Three Robot Role Factors*

Factor	*1*	*2*	*3*
1. Human role	--	.364**	.080
2. Supportive role		--	-.161*
3. Subordinate role			--

*significant at the .05 level (two-tailed)
**significant at the .01 level (two-tailed)

Table 18. *Correlations between the Three Robot Characteristic Factors and the Three Robot Role Factors*

Factor	Human role	Supportive role	Subordinate role
1. Performance-oriented traits	.287**	.560**	-.089
2. Socially-oriented traits	.681**	.454**	-.064
3. Non-productive traits	-.231**	-.229**	.231**

**significant at the .01 level (two-tailed)

The hypothesized relationships between robot roles and robot characteristics were largely supported. The human role factor was strongly positively correlated with socially-oriented traits and, to a lesser but still significant degree, with performance-oriented traits. It was negatively correlated with non-productive traits. The supportive role factor was positively correlated with performance oriented traits and, to a slightly lesser degree, with socially-oriented traits. Like the human role factor, the supportive role factor was negatively correlated with non-productive traits. Lastly, as hypothesized, the subordinate role factor was positively correlated with non-productive traits.

Age differences in robot role assignments were investigated through a multivariate analysis. The assumption of equality of covariance matrices between groups was found to hold, as Box's M test was non-significant, *Box's M* = 10.89, p =.100. A MANCOVA, with age group (younger, older) as the independent variable, the three robot roles (human role, supportive role, and subordinate role) as the dependent variables, and technology experience and robot experience as covariates was conducted. The analysis was conducted on 60 valid younger adult cases and 113 valid older adult cases.

With technology experience and robot experience controlled for, age was found to have a significant, albeit small, effect on the roles that participants indicated their robot as having, Pillai's Trace statistic $F(3,167) = 4.54$, $p = .004$. Univariate tests indicated that younger adults mean scores for human roles, $F(1, 169) = 4.97$, $p = .027$, $\eta_p^2 = .03$. supportive roles, $F(1, 169) = 4.00$, $p = .047$, $\eta_p^2 = .02$, and subordinate roles, $F(1, 169) = 8.41$, $p = .004$, $\eta_p^2 = .05$, were all greater than mean scores of older adults for these roles. Technology experience, $F(3, 167) = .41$, $p = .743$, and robot experience , $F(3, 167) = 2.63$, $p = .052$, did not have significant effects on robot role scores. The graph in Figure 7 shows the mean scores for older and younger adults for the three robot roles factors. As seen in the graph, older adults appeared more moderate in their assignment of roles for robots compared to younger adults. Thus, even with technology experience and robot experience controlled for, age appears to be related to the roles that participants foresee their robot having, with younger adults assigning more roles to robots than older adults.

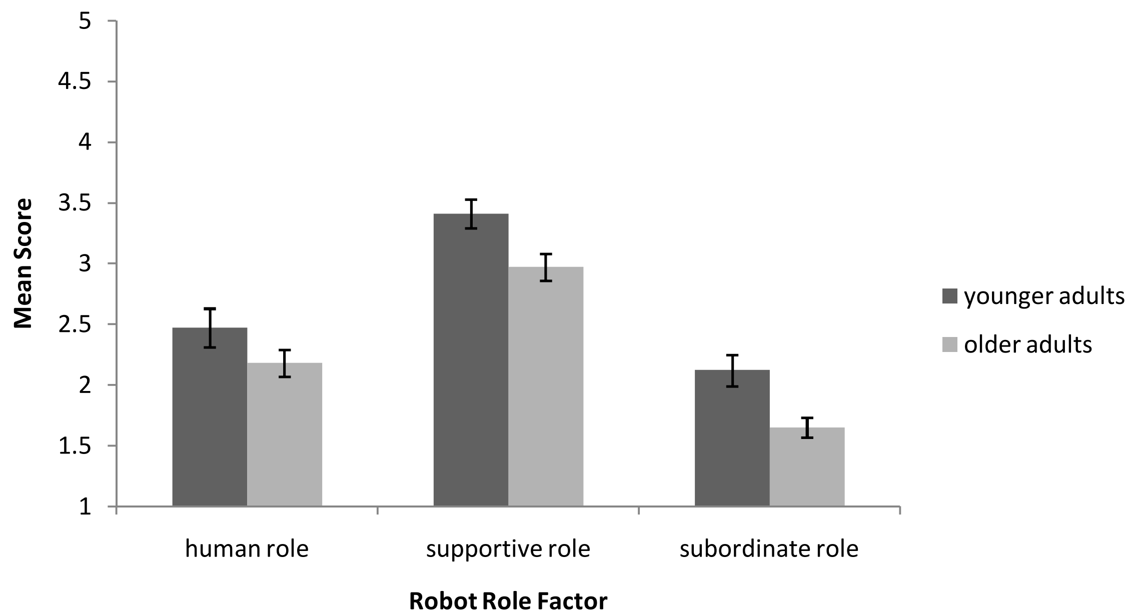

Figure 7. Mean scores of younger and older adults for the three robot role factors. Error bars are standard errors of the mean.

TAM-Related Variables

Participants were asked to indicate their agreement with eight statements about their imagined robot, four relating to the usefulness of the robot and four to the ease of using the robot. The statements were modified from Davis' (1989) original technology acceptance model (TAM) study on acceptance of computer software. Thus, participants' beliefs about the usefulness and ease of use of their imagined robots could be compared against results from the original study, which have been replicated for other types of technology (e.g., Adams, Nelson, & Todd, 1992). A Likert scale was used from 1 = "strongly disagree" to 5 = "strongly agree". A response of "don't know" was counted as a missing value.

First, the internal consistency reliability of the usefulness and ease of use scales were investigated. Cronbach's alpha were high for both, $\alpha = .92$ and $\alpha = .90$, respectively, and comparable to levels reported by Davis (1989) in Study 2 (.98, .94). The correlations between all eight usefulness and ease of use items are available in Appendix L. Next, to assess the factorial validity, the eight items were run through a principal components extraction with a promax rotation. The principal components extraction was selected to replicate the Davis study, although the specific type of oblique rotation was not specified in that study. The factorability of the nine items was acceptable with a KMO measure of sampling adequacy at .874 and a significant Bartlett's test of sphericity, $\chi^2(28) = 1005.47$, $p < .001$.

The principle components analysis revealed a two-component model conforming to the TAM, with usefulness and ease of use as the components. The component correlation matrix and structure matrix from the analysis are available in Appendix L. The pattern matrix with component loadings and communalities for the two-component solution is presented in Table 19. Table 19 also includes component loadings from Davis (1989) for comparison. Ease of use explained 64% and usefulness explained 15% of the variance in initial eigenvalues, for a total of 80% of the initial eigenvalues variance explained. Component loading from this study and the Davis (1989) study were comparable. Unlike the original study, however, ease of use was found to explain more variance than usefulness.

Table 19. *Component Weights and Communalities Based on a Principle Components Analysis with Promax Rotation for Eight Items from the Technology Acceptance Model (N=174) with Comparison to Component Weights from Davis (1989)*

	Component Weights[1]		Davis (1989)[2]		Communalities
Item	**Ease of Use**	**Usefulness**	**Ease of Use**	**Usefulness**	**Extraction**
Controllable	0.92		0.83		0.79
Easy to use	0.91		0.91		0.83
Easy to learn	0.88		0.97		0.74
Easy to become skillful	0.81		0.91		0.76
Increase productivity		1.00		0.98	0.84
Increase performance		0.95		0.98	0.83
Effectiveness		0.87		0.94	0.85
Useful		0.61		0.88	0.72

[1]Components with weightings <.4 are suppressed; [2] Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quarterly, 13,* 319-339.

Table 20. *Descriptive Statistics for Ease of Use and Usefulness Components*

Factor	**No. of items**	**N**	**Mean**	**Std. Dev.**	**Skewness**	**Kurtosis**	**Cronbach's alpha**
Ease of use	4	174	3.84	1.00	-1.07	1.00	.90
Usefulness	4	178	4.07	1.00	-1.37	1.66	.92

Participants were assigned mean scores for ease of use and usefulness components. The mean and standard deviation of scores are presented in Table 20. Overall, participants indicated moderately high beliefs that their imagined robots would be both useful and easy to use.

Age group differences in the means of ease of use and usefulness were investigated through a multivariate analysis. Box's M test was performed to evaluate the assumption of the equality of covariance matrices for the two age groups. The test indicated a violation of this assumption, *Box's M* = 11.07, $p = .012$. To investigate whether the violation was due to outliers, Mahalanobis distances for the two components were calculated. The criterion was set at $\chi^2(2, N = 180) = 9.21$ at $p < .01$. Seven distances were found to exceed this criterion. The Box's M test was rerun to evaluate the effect of removing the outliers on the equality of the covariance matrices, and was found to be non-significant, *Box's M* = 3.35, $p = .348$. The descriptive statistics for the ease of use and usefulness componenet, with outliers removed, are presented in Table 21 and presented visually in Figure 8. A paired t-test, with a Bonferroni correction at the .025 level, indicated usefulness scores as being significantly greater than ease of use scores, $t(166) = 4.00$, $p < .001$. Thus, it appears that participants imagined that their robot would be more useful than easy to use, although scores of the two variables were found to be significantly correlated, $r(167) = .54$, $p < .001$.

A MANCOVA with age group (younger, older) as the dependent variable, TAM-related variable scores (ease of use, usefulness) as the dependent variables, and technology experience and robot experience as covariates was conducted. The analysis indicated a non-significant effect of age on TAM-related variable scores, Pillai's Trace statistic $F(2,159) = .14$, $p = .869$. Technology experience had a significant, although weak relationship, with the TAM-related variable scores, $F(2,159) = 6.57$, $p = .002$, $\eta_p^2 = .076$. Univariate tests indicated significant relationships between technology experience and ease of use, $F(1,160) = 6.05$, $p = .015$, $\eta_p^2 = .04$, and technology experience and usefulness, $F(1,160) = 12.68$, $p < .001$, $\eta_p^2 = .11$, with more technology experience related to higher scores for both factors. Robot experience was not significantly related to TAM-related variable scores, $F(2,159) = .381$, $p = .684$. Thus, technology experience, but not age or robot experience, appears to be related to participant's perceptions about the ease of using and usefulness of their imagined robot.

Table 21. *Descriptive Statistics for Ease of Use and Usefulness Factors with Outliers Removed*

Factor	**Group**	**N**	**Mean**	**Std. Dev.**	**Skewness**	**Kurtosis**
Ease of use	Younger adults	59	4.05	0.78		
	Older adults	105	3.87	0.94		
	Total	167	3.93	0.89	-0.90	0.81
Usefulness	Younger adults	59	4.41	0.75		
	Older adults	109	4.07	0.86		
	Total	171	4.18	0.84	-1.10	0.98

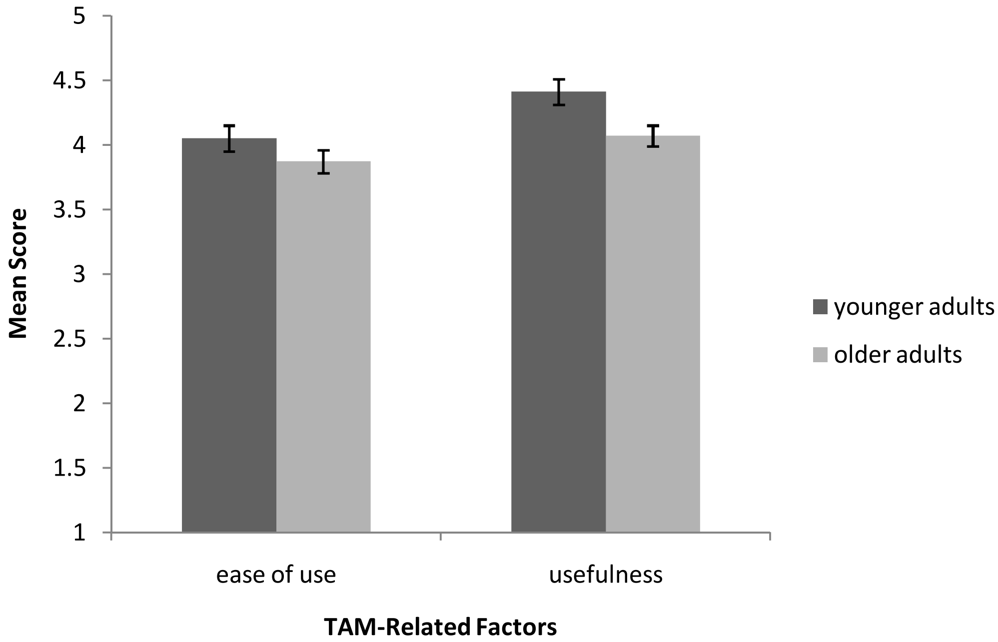

Figure 8. Mean scores of younger and older adults for ease of use and usefulness of their imagined robot. The error bars are standard erors of the mean.

Attitudinal and Intentional Robot Acceptance

Dependent variables in the questionnaire were attitudinal acceptance and intentional acceptance. Each variable contained three 5-point scales to which participants were instructed to indicate their attitudes about the robot they imagined and their intention to purchase the robot they imagined if it were available for purchase. The internal consistency reliability of the scales were examined through Cronbach's alpha and found to be high for both attitudinal ($\alpha = .91$) and intentional ($\alpha = .96$) acceptance scales for 171 and 169 valid cases, respectively. These alphas were comparable to those in Van Ittersum et al. (2007), who found alphas of .96 and .98 on these two scales. Scores on the two scales were significantly correlated $r(178) = .580$, $p < .001$. The correlation between items in the attitudinal and intentional acceptance scales is available in Appendix M.

With reliability of the items in the scales supported, the mean scores for each participant for attitudinal acceptance and intentional acceptance of their imagined robot were calculated. Descriptive statistics for the two acceptance scales are presented in Table 22. The graph in Figure 9 displays the mean scores of acceptance for younger and older adults. A paired t-test indicated that the mean score of attitudinal acceptance was significantly greater than the mean score of intentional acceptance. So, whereas participants indicate moderately-high positive attitudes toward their imagined robots, they indicated more conservative estimates about whether they would actually purchase the robot.

Table 22. *Descriptive Statistics for Attitudinal and Intentional Acceptance Scales*

Acceptance	**Group**	**N**	**Mean**	**Std. Dev.**	**Skewness**	**Kurtosis**	**Cronbach's alpha**
Attitudinal	Younger adults	60	4.13	0.94			
	Older adults	115	3.19	1.20			
	Total	178	3.99	1.11	-1.20	0.87	.91
Intentional	Younger adults	60	3.57	1.18			
	Older adults	117	3.07	1.37			
	Total	180	3.25	1.32	-0.39	-1.03	.96

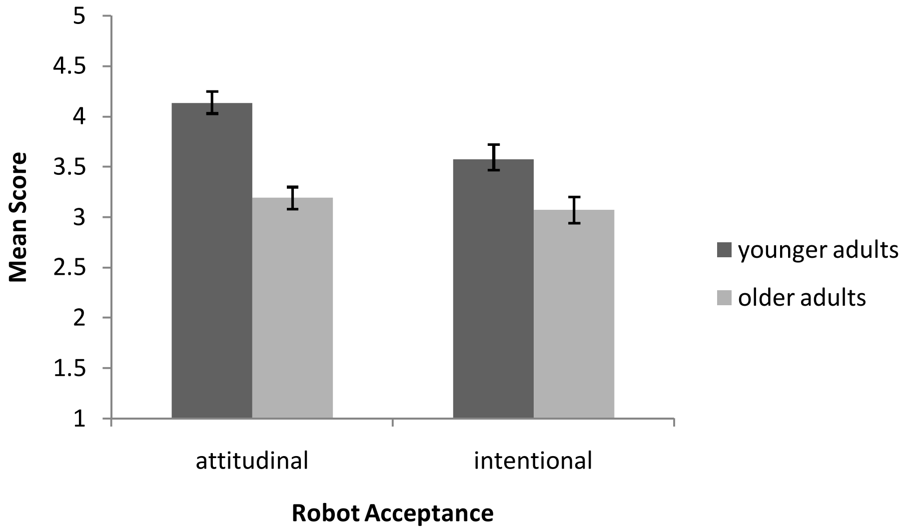

Figure 9. Mean scores of younger and older adults on attitudinal and intentional acceptance scales. Error bars are standard errors of the mean.

Age group differences in attitudinal and intentional acceptance of participants' prototypical robots were examined through a multivariate analysis. The equality of covariance matrices was measures through Box's M test and found to be non-significant, *Box's M* = 5.40, $p = .150$. A MANCOVA was performed with age group (younger, older) as the independent variable, acceptance (attitudinal, intentional) as the dependent variable, and technology experience and robot experience as covariates. The analysis indicated that with technology and robot experience controlled for, age did not have a significant effect on robot acceptance, Pillai's Trace statistic $F(2, 170) = .324$, $p = .724$. Technology experience was found to have a significant, although weak, relationship with robot acceptance $F(2, 170) = 3.74$, $p = .026$, $\eta_p^2 = .042$. Univariate between-subjects test indicated technology experience having a significant relationship with both attitudinal acceptance scores, $F(1, 171) = 4.12$, $p = .044$, $R^2 = .04$ and intentional acceptance scores,

$F(1, 171) = 7.09$, $p = .008$, $R^2 = .09$, with more technology experience related to greater acceptance. Robot experience was not significantly related to acceptance, $F(2, 170) = 3.74$, $p = .528$. Thus, attitudinal and intentional acceptance of robots appears to be related to current use of other technologies, but not to age or familiarity with existing robots.

TAM-related variables, robot characteristics, and robot acceptance. According to the TAM, individuals' beliefs about the ease of use and usefulness of a technology can predict attitudinal acceptance and intentional acceptance of that technology (Lederer, Maupin, Sena, & Zhuang, 2000). It was hypothesized that the characteristics that participants associated with their prototypical home-based robot would significantly increase the amount of variance in attitudinal and intentional acceptance of the robot over that explained by ease of use and usability alone. The correlations between the three robot characteristic factors (performance-oriented traits, socially-oriented traits, and non-productive traits), the two TAM-related variables (ease of use and usefulness), and the two dependent variables of robot acceptance (attitudinal acceptance and intentional acceptance) are presented in Table 23. Performance-oriented and socially-oriented robot traits were both found to be significantly positively correlated with the two TAM-related variables and the two robot acceptance variables, although the correlation was stronger for performance-oriented traits than socially-oriented traits. Non-productive traits were significantly negatively correlated with both TAM-related variables and both robot acceptance variables.

Table 23. *Correlations between Robot Characteristic Scores, Technology Acceptance Model (TAM) scores, and Acceptance Scores*

		Acceptance		**TAM**	
Scale		Attitudinal	Intentional	Ease of Use	Usefulness
Robot characteristics	Performance-oriented	.326**	.376**	.422**	.471**
	Socially-oriented	.248**	.315**	.338**	.302**
	Non-productive	-.292**	-.268**	-.370**	-.367**
Acceptance	Attitudinal			.565**	.605**
	Intentional			.517**	.518**

** significant at the .01 level (two-tailed)

A hierarchical multiple regression analysis was performed to investigate the effect of adding robot characteristic variables to TAM-related variables in predicting robot acceptance. Variance-inflation factors (VIF) were calculated to examine collinearity. No VIF value was greater or equal to 4, suggesting multicollinearity was not an issue (Garson, 2008a). Coefficients and model summaries for the regression analyses performed on attitudinal acceptance and intentional acceptance are presented in Table 24 and Table 25, respectively.

In the first model for regression onto attitudinal acceptance, usefulness and ease of use were entered, followed by the three robot characteristic variables in the second model. The analysis indicated usefulness and ease of use as significantly predicting attitudinal acceptance scores. These TAM-related variables explained a significant proportion of the variance in attitudinal acceptance scores. The addition of the robot characteristic variables did not significantly increase the amount of variance explained in attitudinal acceptance over that explained by the TAM-related variables, R^2-*change* = .01, *F-change* (3, 158) = .878, p = .454.

Table 24. *Regression of Technology Acceptance Model (TAM) Scores and Robot Characteristic Scores on Attitudinal Acceptance Scores*

		Attitudinal Acceptance					
		Coefficients			Model Summary		
Model	**Variables**	β	*t*	*p*	R^2	*F*	*p*
TAM	Usefulness	.37	4.83	<..01**	.32	38.2[1]	<.01**
	Ease of use	.27	3.52	<.01**			
Robot Characteristics	Performance-oriented	.19	2.05	.04*	.14	9.2[2]	<.01**
	Socially-oriented	.13	1.60	.11			
	Non-productive	-.17	-2.00	.05			
TAM + Robot Characteristics	Usefulness	.35	4.25	<.01**	.33	15.8[3]	<.01**
	Ease of use	.25	3.06	<.01**			
	Performance-oriented	-.03	-0.32	.75			
	Socially-oriented	.08	1.15	.25			
	Non-productive	-.08	-1.03	.30			

[1]*F*(2, 161); [2]*F*(3, 168); [3]*F*(5, 158)
*significant at .05 level
** significant at .01 level

Table 25. *Regression of Attitudinal Acceptance Scores, Technology Acceptance Model (TAM) Scores, and Robot Characteristic Scores on Intentional Acceptance Scores*

		Intentional Acceptance					
		Coefficients			Model Summary		
Model	**Variables**	β	*t*	*p*	R^2	*F*	*p*
Attitudinal Acceptance	Attitudinal acceptance	.58	9.07	<.01**	.34	82.2[1]	<.01**
TAM	Usefulness	.34	4.40	<..01**	.30	35.4[2]	<.01**
	Ease of use	.28	3.66	<.01**			
Attitudinal Acceptance + TAM	Attitudinal acceptance	.40	5.37	<.01**	.41	37.0[3]	<.01**
	Usefulness	.19	2.50	.01*			
	Ease of use	.18	2.35	.02*			
Robot Characteristics	Performance-oriented	.24	2.78	.01*	.18	12.1[4]	<.01**
	Socially-oriented	.19	2.38	.01*			
	Non-productive	-.10	-1.21	.23			
Attitudinal Acceptance + TAM + Robot Characteristics	Attitudinal acceptance	.38	5.16	<.01**	.43	19.4[5]	<.01**
	Usefulness	.17	2.04	.04*			
	Ease of use	.14	1.82	.07			
	Performance-oriented	.07	0.80	.42			
	Socially-oriented	.11	1.65	.10			
	Non-productive	.01	0.13	.90			

[1]$F(1, 162)$; [2]$F(2, 164)$; [3]$F(3, 161)$; [4]$F(3, 170)$; [5]$F(6, 157)$

* significant at .05 level

** significant at .01 level

For intentional acceptance, attitudinal acceptance was added as the predictor in the first model, usefulness and ease of use in the second model, and the three robot characteristic variables in the third model. Attitudinal acceptance scores significantly predicted intentional acceptance scores, $\beta = .58$, $t(178) = 9.07$, $p < .001$ and explained a significant amount of variance in intentional acceptance scores, $R^2 = .34$, $F(1,162) = 82.17$, $p < .001$. The addition of the TAM-related variables in the model significantly increased the amount of variance explained in intentional acceptance scores. R^2-*change* = .07, *F-change* (3, 158) = 9.69, $p < .001$. In this model, attitudinal acceptance scores, $\beta = .40$, $t(178) = 5.37$, $p < .001$, usefulness, $\beta = .19$, $t(171) = 2.50$, $p = .013$, and ease of use, $\beta = .18$, $t(167) = 2.35$, $p = .020$, significantly predicted intentional acceptance scores. The total R^2 explained by this model was .41. The addition of the three robot characteristic variables into the model did not explain significantly more variance in intentional acceptance scores over those explained by attitudinal acceptance scores, usefulness, and ease of use, R^2-*change* = .02, *F-change* (3, 157) = 1.64, $p = .183$.

To summarize the findings of the regression analyses: The hypothesis that characteristics of participants' prototypical home-based robots would significantly add to the amount of variance in participants' attitudinal and intentional acceptance of a home-base robot explained by TAM-related variables was not supported. Although the robot characteristics themselves were predictive of both types of acceptance that were assessed, it appears that these variables were completely mediated by the variables of usefulness and ease of use (using the definition of mediation proposed by Baron & Kenny, 1986). What the regression analysis did reveal was that usefulness and ease of use were predictive of participants' attitudinal acceptance of a robot in their home; usefulness, ease of use and attitudinal acceptance were predictive of intentional acceptance.

Recommendation of robot to others. Participants were asked to indicate how likely they would be to recommend the robot they imagined in their home to others, on a scale from 1 = "not recommend" to 5 = "recommend". Participants' mean score on the recommendation scale was 3.83 (SD = 1.28), on 179 valid cases. An ANCOVA, with age group (young, old) as the independent variable, technology experience and robot experience as covariates, and recommendation score as the dependent variable, was performed. The analysis revealed no significant difference in the mean score of younger adults (M = 4.05, SD = 1.20) and older adults (M = 3.72, SD = 1.30), $F(1, 172) = .174$, $p = .677$, suggesting they would be equally likely to recommend their robot to others. There was also no significant effect of technology experience, $F(1, 172) = 3.69$, $p = .056$, or robot experience, $F(1, 172) = .213$, $p = .645$, on recommendation scores.

Participants were instructed to write who they would recommend their robot to. A total of 109 participants responded (61%), of which 45 were younger adults (75% of younger adults) and 63 were older adults (54% of older adults). The mean recommendation score of participants who responded to the open-ended question (M = 4.12, SD = 1.03) was significantly greater than those participants who did not respond to this question (M = 3.37, SD = 1.46), $F(1, 177) = 16.12$, $p < .001$.

Participants' responses corresponded to seven major categories of who they would recommend their robot to: Family, friends, everyone/anyone, older adults, people with disabilities, co-workers, and people who are busy/are responsible for the home (e.g., single parents). Responses that did not match these categories were categorized as "other". There were 175 total responses in these categories and in the "other" category, or approximately 1.6 categories per person. The percentage of responses that fell into each category of who participants would recommend their robot is presented in Figure 10. Recommending the robot to friends and family were the most common responses, comprising approximately 70% of the total responses. Approximately 12% of the total responses were recommendations to individuals with particular needs such as older adults, individuals with disabilities, and individuals who are busy. The number of younger and older adult participants in each robot recommendation category is presented in Table 26. Chi-square analyses indicated that the only significant difference in recommendations between younger and older adults was in recommendations of their robot to co-workers; only younger adults indicated they would do so. Overall, younger and older adults were equally likely to recommend their robot to certain groups of people.

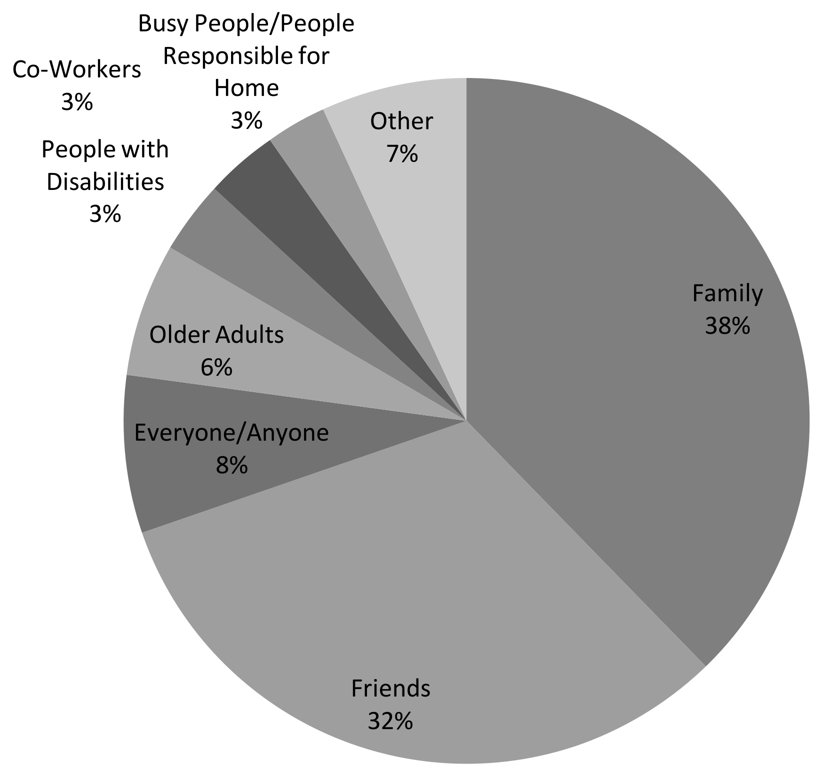

Figure 10. Who participants indicated they would recommend their robot to. Percentages are out of total responses.

Table 26. *Who Participants Would Recommend Their Robot To*

Category	**Group**	**N Recommend**	**Pearson $\chi^2(1, N = 108)$**	***p***
Family	Younger adults	30	1.35	0.25
	Older adults	35		
	Combined	65		
Friends	Younger adults	26	1.09	0.30
	Older adults	30		
	Combined	56		
Everyone/Anyone	Younger adults	7	0.90	0.34
	Older adults	6		
	Combined	13		
Older Adults	Younger adults	5	0.07	0.79
	Older adults	6		
	Combined	11		
Individuals w/Disabilities	Younger adults	2	0.18	0.67
	Older adults	4		
	Combined	6		
Co-workers	Younger adults	6	8.89	.003**
	Older adults	0		
	Combined	6		
Busy Individuals	Younger adults	3	1.90	.168
	Older adults	1		
	Combined	4		
Other	Younger adults	4	0.39	0.54
	Older adults	8		
	Combined	12		

** significant age differences at .01 level

Robot Tasks

Participants were presented with 15 tasks that robots could perform in the home. These tasks were selected to include more and less interactive tasks as well as more and less critical tasks. Participants were instructed to indicate how willing they would be to let robots perform those tasks on a scale from 1 = "not at all" to 5 = "to a great extent". A response of "don't know/doesn't apply to me" was counted as a missing value.

To investigate the underlying factor structure of robot tasks that participants would let robots perform in their home, the robot task items were run though a principle axis factor analysis procedure with a promax rotation (kappa = 4). Factor loadings with absolute values under .4 were suppressed, and only eigenvalues over 1.0 were extracted. The factorability of the 15 items was acceptable with a KMO measure of sampling adequacy value was .893 and a significant Bartlett's test of sphericity, $\chi^2(105, N = 178) = 1099.25$, $p < .001$.

The factor analysis resulted in a three-factor model, as no other factors with eigenvalues above 1.0 were present. The first factor accounted for 43% of the initial eigenvalues and the second and third factors accounted for 9% and 8%, respectively. Thus, the total variance accounted for by the three-factor model was 60% of the initial eigenvalues and 51% of the extraction sums of squared loadings. The initial factor extraction required 17 iterations and the rotation converged in seven iterations. The factor correlation matrix and structure matrix for the analysis are available in Appendix N. The pattern matrix with factor weights and communalities for the three robot tasks factors are presented in Table 27.

The three task factors appeared to differ by the interaction that would be required between robot and human user as well as by how frequently those tasks would be performed. The first factor was largely composed of tasks in which the robot would need to be actively engaged with the user (e.g., have conversations with the user). The second factor included tasks which would greatly help the user but that would not be performed by the robot frequently (e.g., warn the user about a danger in the home). The third factor included tasks which the robot would perform frequently, but the robot would interact with the human only as a servant (e.g., bringing objects from another room to the user). The three factors were thus labeled "interactive tasks", "infrequent tasks", and "service tasks".

Each participant was given a mean score for each of the robot task factors. The task of showing the user how to use other technology was included in the means of both the interactive and the infrequent task factors, since its loading on both factors were similar. The descriptive statistics for the three factors are presented in Table 28 and the correlations between them in Table 29. Overall, participants indicated a moderate to large interest in having robots perform interactive, infrequent, and service tasks. Scores on the three robot tasks factors were highly correlated, suggesting that willingness to let robots perform one type of task was indicative of willingness to let robots perform other types of tasks.

Paired sample t-tests, with a Bonferroni correction at the $p = .0167$ level, were conducted to look at the differences in means between the three task factors. The mean score of willingness to let robots perform infrequent tasks was significantly greater than the mean score of willingness to let robots perform service tasks, $t(177) = 6.98$, $p < .001$;

the mean score of willingness to let robots perform infrequent tasks was significantly greater than the mean score of willingness to let robots perform interactive tasks, $t(178) = 16.47$, $p < .001$; the mean score of willingness to let robots perform service tasks was significantly greater than that of interactive tasks, $t(179) = 4.60$, $p < .001$. Thus, participants were most willing to have robots perform infrequent, albeit important, tasks, followed by service tasks, and least willing to have robots perform interactive tasks with them.

The effect of age group on willingness to have robots perform different types of tasks was investigated. A MANCOVA, with age group (younger, older) as the dependent measure and robot tasks (interactive, infrequent, and service) as the dependent variables was conducted. Technology experience, robot experience, health-complexity, and living situation (living alone or with others), were included as covariates. It was predicted that all four covariates would be related to the types of tasks that individuals would want robots to perform in their home (e.g., individuals who live alone might have more interest in interactive tasks or individuals with health issues might have more interest in service tasks, compared to individuals who live with others or have fewer health issues, respectively). Box's M test was non-significant, *Box's M* = 8.89, $p = .195$, indicating assumption of equality of the covariance matrices between groups was met.

The MANCOVA analysis indicated that with technology experience, health experience, health, and living situation controlled for, age had a significant effect on the types of tasks that participants were willing to let robots perform in their home, Pillai's Trace statistic $F(3, 131) = 5.52$, $p = .001$, $\eta_p^2 = .11$. The univariate analysis indicated that older adults scores on willingness to have robots perform infrequent tasks were significantly greater than those for younger adults, $F(1,133) = 6.88$, $p = .010$. The mean willingness scores for interactive task, $F(1,133) = 034$, $p = .850$, and for service tasks, $F(1,133) = 1.48$, $p = .230$, were not significantly different between younger and older adults. The graph presented in Figure 11 shows the means scores of older and younger adults for each of the three robot task factors. None of the covariates had significant relationships with willingness scores on the three robot tasks factors.

Trust in Robot Scenario

Participants were presented with a scenario in which they were unable to take care of themselves, due to illness or injury. They were asked to indicate whether they would chose to remain in their home under the care of a robot or move to a care facility. The number of participants who selected each choice is presented in Table 30.

When given the choice between remaining in the home and relying on a robot for care or moving to a care facility, the majority of partcipants (69 %) chose the option of remaining in their home. Another 20% of participants did not know which they would choose and only 11% indicated a preference for moving to a care facility and not having to rely on a robot. A chi-square analysis was run to see if the number of older and younger adults selecting each choice were significantly different. The non-significant result (see Table 30) indicated no difference in the number of younger and older adults who would remain in their home under the care of a robot, would move to a care facility, or would not know what they would do in this situation. Even with ‘don’t know’ responses removed, there was no significant age-related difference in preferences for staying in the home with a robot versus moving to a care facility.

Trust in robot. After indicating whether they would chose to remain in their home or move to a care facility, participants were asked to indicate how much they would trust a robot to take care of them in this situation on a scale from 1 = “not trust” to 5 = “trust”. Of the 170 participants who responded to this question, the mean score on the scale was 3.36 (SD = 1.25), suggesting that, overall, participants had a moderate amount of trust in the robot.

Table 27. *Factor Weights and Communalities Based on a Principle Axis Analysis with Promax Rotation for Fifteen Items of Robot (N = 178)*

	Factor Loadings[1]			**Communalities**	
Item	**Interactive Tasks**	**Infrequent Tasks**	**Service Tasks**	**Initial**	**Extraction**
Teach me more about a hobby or topic of interest	0.89			0.59	0.61
Give me information about the weather, news, etc.	0.76			0.58	0.57
Have a conversation with me	0.74			0.50	0.50
Help motivate me to exercise	0.67			0.59	0.57
Play games with me	0.54			0.41	0.40
Help me stick to a diet	0.50			0.60	0.59
Teach me a new skill	0.46			0.55	0.50
Remind me to take my medication	0.46			0.48	0.47
Warn me about a danger in my home		0.81		0.46	0.57
Scare away an intruder		0.70		0.45	0.46
Show me how to use other technology	0.42	0.43		0.58	0.54
Inform my doctor if I have a medical emergency		0.42		0.46	0.38
Bring me things I need from another room in my home			0.80	0.42	0.64
Make meals or cook for me			0.57	0.45	0.53
Help me with housework			0.52	0.35	0.35

[1]Factor weights <.4 are suppressed

Table 28. *Descriptive Statistics for the Three Robot Tasks Factors*

Factor	No. of Items	Group	N	Mean	Std. Dev.	Skewness	Kurtosis	Cronbach's Alpha
Interactive tasks	9	Younger adults	60	3.22	1.04			
		Older adults	117	2.95	1.02			
		Total	180	3.03	1.04	-0.13	-0.81	0.90
Infrequent tasks	4	Younger adults	60	3.89	1.03			
		Older adults	115	4.04	0.94			
		Total	178	3.98	0.98	-1.02	0.30	0.75
Service tasks	3	Younger adults	60	3.68	1.08			
		Older adults	117	3.29	1.09			
		Total	180	3.41	1.11	-0.23	-0.77	0.72

Table 29. *Correlations between the Three Robot Task Factors*

Factor	*1*	*2*	*3*
1. Interactive tasks	--	.704**	.487**
2. Infrequent tasks		--	.433**
3. Service tasks			--

** significant at the .01 level (two-tailed)

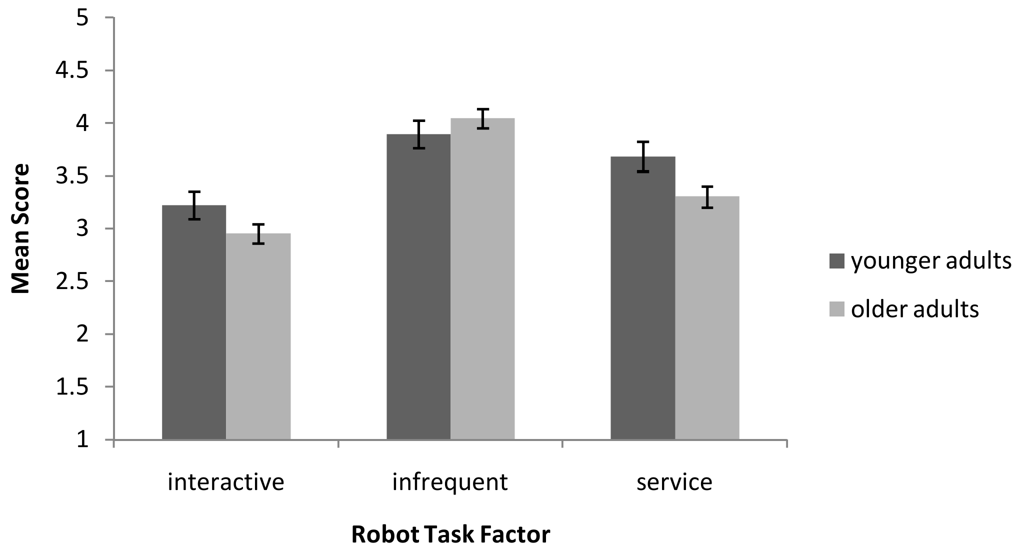

Figure 11. Mean scores of younger and older adults for the three robot task factors: interactive, infrequent, and service tasks. Error bars are standard errors of the mean.

Table 30. *Participants' Choice between Remaining in the Home under a Robot's Care and Robot Moving to a Care Facility*

	N			**With don't know included**		**With don't know excluded**	
Group	Remain living in home and use a robot	Move to a care facility and not use a robot	Don't know	**Pearson** $\chi^2(2, N = 170)$	***p***	**Pearson** $\chi^2(1, N = 136)$	***p***
Younger adults	40(67%)	11 (18%)	9 (15%)				
Older adults	77(70%)	8 (7%)	25 (23%)	5.47	0.07	3.92	0.07
Combined	117(69%)	19(11%)	34(20%)				

A two-way ANOVA, with choice (stay in home and use a robot, move to care facility, or don't know) and age group (younger, older) as the independent variables and trust score as the dependent variable, was performed. The trust scores of participants were found to be significantly different depending on participants' choice about what they would do if they became unable to care for themselves, $F(2, 158) = 38.81$, $p < .001$. Tukey's post hoc tests indicated that the trust scores of participants who had previously indicated that they would rather stay in their home and use a robot if they became unable to care for themselves ($M = 3.84$, $SD = .96$) were greater than the scores of those who indicated they would rather move to a care facility ($M = 1.84$, $SD = 1.17$), $p < .001$, and those who didn't know what they would do ($M = 2.62$, $SD = 1.08$), $p < .001$. There was also a significant difference in trust scores between participants who indicated they would rather move to a care facility and those that didn't know which they would choose in the situation, $p = .027$. Younger adults' trust scores ($M = 3.35$, $SD = 1.23$) did not significantly differ from older adults' trust scores ($M = 3.21$, $SD = 1.24$), $F(1,158) = .47$, $p = .496$. The interaction between choice and age were also not significant, $F(2, 158) = .08$, $p = .925$. To summarize, participants' trust in robots to take care of them when they are unable to take care of themselves was strongly related to their choice to stay in their home as opposed to move to a care facility, regardless of their age.

Trust influences. Participants were asked what would influence their decision to trust a robot to take care of them in the event that they could not take care of themselves. There were 160 participants who responded to this question (57 younger and 100 older). Five participants provided non-relevant responses and were not included in analysis.

Commonalities in the remaining responses were used to create 10 major categories capturing influences on trust in robots. These categories are available in Appendix O.

Participants provided a total of 220 category responses to what would influence their decision to trust a robot to take care of them. The percentage of responses corresponding to each category of influences on trust in robots is presented in Figure 12. As seen in the figure, over half (55%) of participants' responses were related to evidence of the robot's ability to perform the tasks required in care-giving. This category contained seven sub-categories about the type of evidence that participants referred to. About 75% of responses in this category were related to three sub-categories: information about the reliability of the robot, information about the robot's intelligence and medical knowledge, and first-hand experience with the robot. When participants mentioned reliability, they often stated they would need proof that the robot would perform consistently over time (e.g., "reliability proven over time"). When participants mentioned information about the robot's intelligence and medical knowledge, they stated that they would need evidence that the robot had the medical know-how and reasoning ability to perform care-giving activities (e.g., "It would have to have full knowledge of all circumstances of health problems and situations, like someone in a nursing home or rehabilitation facility"). When participants mentioned first-hand experience, they stated that seeing and experiencing the robot for themselves would influence their decisions about how much to trust the robot (e.g., "trying it for myself"). After these three response sub-categories, the next most stated evidence for the robot's performance ability mentioned by participants was second-hand experience, or gaining information about the experience that others have had with the robot (e.g., "consumer reviews"; "recommendations/experience of others”). Fewer participants indicated that information about the robot’s physical capabilities (e.g., “capable of helping me up…should I fall”), limitations and types of error (e.g., “understanding its functional limitations – what creates failure mode”) and capability to handling unexpected events (e.g., “react to unexpected things”) would influence their decision about how much to trust the robot.

The remaining 45% of responses that were not categorized as evidence for performance were divided among nine categories. Approximately 8% of responses were about getting more general information about robots (e.g., “to learn more about robots”). Another 6% were about how easily the robot would be to use (e.g., “understanding how to use the thing. I find items which continue to proliferate difficult to program - to have function correctly...”). Participants also indicated that the severity of their own condition would influence their decision about whether to trust a robot to take care of them (5% of responses; e.g., “the amount of my incapacity to take care of my needs”), although it was often not clear how it would influence their choice.

Approximately 5% of participants’ responses were about whether current technology was advanced enough to make robot care-givers feasible (e.g., “I don't think the machines are mostly ready now. I expect them to be later. We are already using many technologies in this area”). Price or cost of care-giving robots was also brought up as a concern in 4% of responses. Some participants suggested that these types of robots would be too costly for most people (e.g., “I think that a robot with technology to perform these duties would be too expensive for most”). Other, less frequent, responses included the human likeness of robots, both in personality and appearance, the idea that robots can never replace humans, and lack of trust in human caregivers and care facilities.

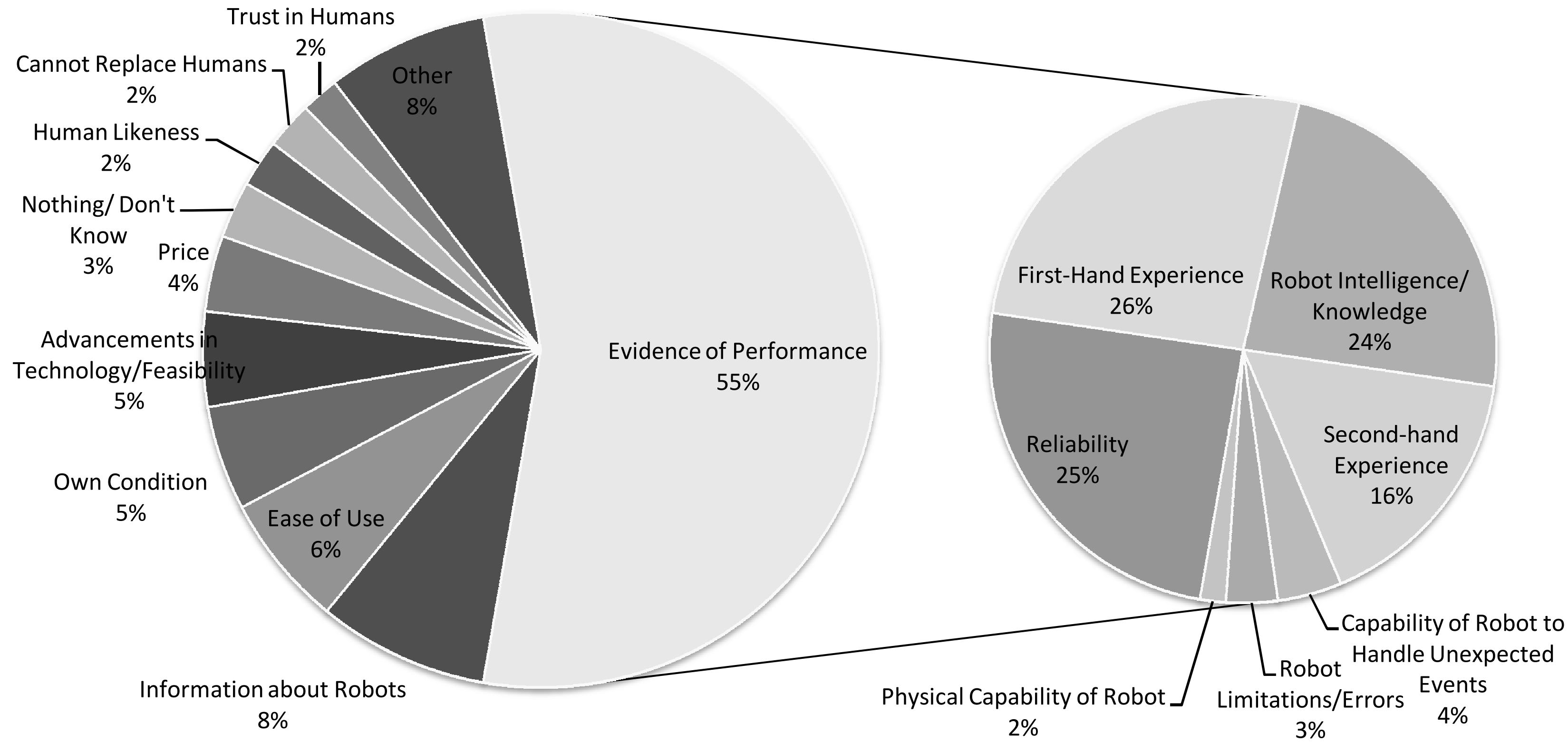

Figure 12. Percent of participants' responses corresponding to categories of what would influence their trust in a robot to take care of them should they be unable to take care of themselves.

Change in Robot Image

It was predicted that, over the course of answering questions about the robot they imagined in their home, participants' images of their robot would change. To investigate this, participants were asked to indicate whether the image of the robot in their home had changed since they described and drew the robot on the blue sheet. Of the 169 participants that answered this question, 45 (27%) indicated that their image of a robot in their home had changed, whereas the remaining participants answered that their image of a robot in their home had remained exactly the same. A chi-square analysis indicated no significant difference in the number of younger and older adults who indicated a change versus no change in their robot image, $\chi^2(1, N = 166) = 3.42$, $p = .064$.

Participants who had indicated changes in the image of the robot in their home were instructed to write what these changes were. The 44 responses that were given were examined for commonalities. Three common responses were found: changes in tasks the robot would perform, changes in the robot's appearance, and changes in how human-like the robot would be.

Of the participants who indicated a change in their robot' image, 50% stated that the change had been in the tasks that their robot would perform. The majority of these changes (93%) were in an increase in the number and types of tasks that robots could perform. For example a younger adult wrote:

> My original thought was to have a robot that could perform simple household tasks such as vacuuming or obeying voice commands to retrieve an item from another room. I now envision my robot going beyond this and being able to protect my home against chemicals and bugs

> as well as intruders, and making me live a healthier lifestyle by providing reminders and motivation to workout, eat, and sleep. I can now envision my robot doing just about anything as long as it doesn't need a personality.

The example above illustrates the change in perception from a robot performing mundane housecleaning tasks, in which the human is not necessarily interacting with the robot, to more critical tasks and tasks which the human and robot would do together.

Of the participants who indicated that they imagined their robot to do more things than they previously considered, 77% mentioned more interactive tasks with the robot, particularly the robot providing information (about weather, news, etc.) and teaching them new skills. For example, an older adult participant initially stated that he: “would like (the robot) to clean my home, cut my lawn, rake and dispose of leaves, water house plants, (and) turn on and off lights”. In answering the question of how the image of the robot in his home had changed, the same participant wrote: “Some things (the robot) might do, such as warn me of danger, teach me a new skill or language.” Another younger adult female participant initially wanted her robot to wash dishes. In responses to the question of how her image of a robot had changed she wrote: “I didn't realize that robots CAN be programmed to teach things, like foreign language, or how to use things, how to fix things”. Overall, participants’ ideas of what robots could be used for changed from non-interactive, manual, tasks to more interactive, teaching and informing, tasks.

Besides changes in the tasks that they imagined robots in their home performing, 20% of participants answering this question indicated that the appearance of their robot had changed. The most stated appearance change was the addition of a screen on the robot, which was mentioned by 55% of these participants. For instance an older adult female stated that “some kind of information/communication screen should be included” to her initial robot image. Another commonality among changes in robot appearance was an increase in the size of the robot, comprising 27% of responses in this category. For example an older adult male participant initially described his robot as being 12" x 12" x 6", but responded that the robot had become "much bigger" in his mind. None of the participants who indicated in increase in the size of their imagined robot provided reasons why the size change was necessary.

In terms of human likeness, 11% of respondents to the question of how their robot's image had changed stated that their robot had become more or less human like. An equal number of participants indicated that their robot had become more humanlike as those that indicated it had become less humanlike. For example an older adult female indicated that her imagined robot had become "more human in looks and capabilities" Another female participant responded that: "I don't think (the robot) will have to resemble a human." So, whereas there was an increase in the number and types of tasks participants imagined their robot would perform, there was no clear pattern about whether participants imagined more or less human-like robots.

Summary of Questionnaire Results and Discussion

The purpose of the questionnaire was to get a broad understanding of the characteristics of individuals' prototypical home-based robots and investigate the relationships of these characteristics to age, robot experience, and technology experience. Additional goals of the research included:

- Identify whether individuals think of robots as more machine-like or humanlike

- Determining whether individuals' prototypical robot characteristics can predict attitudinal and intentional acceptance of robots over that predicted by technology acceptance model (TAM) variables
- Categorize types of tasks that individuals would and would not want robots to perform in their home

Despite a low return rate the results bring us closer to understanding peoples' perceptions about a robot in their home.

First of all, individuals appear to have different ideas about what a robot in their home would look like. When participants were asked to draw and describe a robot in their home, there were many human-like, many machine-like, and many human-like and machine-like robots that were drawn and described. Overall, however, there was a tendency for participants to imagine a more machine-like robot. There was some indication that younger adults viewed robots as being more human-like than older adults, although the relationship between age and appearance was not a strong one.

Despite a tendency towards imagining more machine-like robots, more than half of participants imagined their robot with a head and 40% of participants imagined that their robot had facial features. This suggests that individuals may ascribe some social ability to robots, or in some sense still expect robots to have characteristics of humans. The anthropomorphism of robots has been suggested by Duffy (2003) as a useful mechanism that may allow humans and robots to have meaningful interactions.

What was additionally interesting about the facial features that participants gave to their robot was that these features were not all or none; different types of features, eyes and mouths, were more prevalent. This is not totally surprising, as previous research as shown that eye gaze and lip movements are some of the most important aids in social communication (Haxby, Hoffman, & Gobbini, 2000). In this study, younger adults tended to draw and describe robots with more facial features than did older adults. This further suggests that younger adults may have greater expectations than older adults about the social nature of a robot in their home.

There were a few other interesting results from the drawings and descriptions that participants were asked to make about the robot they imagined in their home:

- When participants indicated the robot's height, they tended to think of the robot as being smaller than themselves.
- The majority of participants imagined robots with arm-like appendages, suggested interaction with the environment. Almost all participants gave their robot gave two arms, suggesting that even participants who imagined machine-like robots were still influenced by human-like features.
- Mobility was also an important characteristic of participants' prototypical robot as most participants indicated ways that the robot could move. The most common form of mobility was legs followed by wheels.
- Only a quarter of participants indicated interaction features, such as buttons or screens on their robot. This may suggest that the way a robot is controlled may not be an important part of individuals' prototypical robot characteristics. An alternative explanation may be that few participants imagined physically interacting with a robot in their home.
- Participants that described types of tasks that a robot in their home would perform largely mentioned mundane tasks such as cleaning. Some

participants did mention other types of tasks associated with security, physical assistance, and control of other devices or machines.

These findings suggest some important characteristics of individuals' prototypical home based robots: Robots tend to be more machine-like than human-like, but still may have heads and facial features, they interact with the world through arm, or arm-like appendages, are mobile (often by having legs), tend to be shorter than humans, and typically perform mundane tasks in the home. This description, however, would be unlikely to capture any individual person's perception of a robot in his or her home.

Beyond the drawings and descriptions that participants provided about a robot in their home, results from other parts of the questionnaire also give insight into how individuals may think about such robots.

Participants were given a large list of possible characteristics of robots and asked to indicate how much those characteristics matched the robot they imagined in their home. A factor analysis suggested three ways that participants thought about robots: as performance-oriented, socially-oriented, or non-productive devices. Although a factor analysis technique is dependent on which variables are used and the subjective interpretation of the results, the differences in participants' scores for these three factors are still informative. Specifically, mean scores of performance-oriented traits were significantly greater than those for socially-oriented traits, which were in turn significantly greater than for non-productive traits. Thus participants imagined robots mostly as helpful, purposeful devices, less as socially-intelligent devices, and least of all as uncontrollable or wasteful devices. Their generally positive views about robots, suggests that measures looking only at fear of robots (e.g., Nomura, Kanda, Suzuki, and

Kato, 2004) may not be sufficient for predicting acceptance of robots. Of course self-selection bias may have played a part in this result, with only individuals having positive views of robots returning the questionnaire.

As expected, socially-oriented trait scores were positively correlated with participants drawing and describing robots with more human-like appearances and facial features, but negatively correlated with machine-like appearances. Performance-oriented trait scores was not related to overall appearance, suggesting that characteristics other than appearance may be more important determinants of whether a robot will be useful. Surprisingly, machine-like appearances were positively correlated with non-productive trait scores. This may suggest more negative views about machine-like robots, or perhaps more uncertainties about being able to control machine-like robots.

Age not did not have a significant effect on the characteristics that participants indicated their robot as having, when technology and robot experience were accounted for. The results do not suggest, however, that older adults had more negative views about robots than did younger adults.

The section in the questionnaire on overall robot roles further revealed the ways that individuals may think of a robot in their home. A factor analysis on nine possible robot roles suggested three types of roles that a robot in the home may take: a human role, a supportive role, and a subordinate role. Participants thought of robots as having supportive roles, such as being assistants or servants, more than they thought of robots as having human roles, such as being a friend; they did not associate their robot as having subordinate roles, such as being like a pet or a toy, as much as they did the other types of roles. This suggests that individuals expect a robot in their home to be an assistive device that is there to carry out specific tasks. The conclusion is enhanced by the positive correlation between supportive role scores and performance-oriented trait scores.

Age was found to be related to the roles that participants expected a robot in their home to have, even with technology and robot experience accounted for. Younger adults assigned more roles to their robot than did older adults. An explanation could be that older adults are more conservative in the roles that they expect a robot in their home to be in. They may be less sure in the role a robot would play in relation to themselves.

Another contribution of the questionnaire to understanding individuals' attitudes and expectations of a robot for their home was the inclusion of TAM variables. Overall, participants expected a robot in their home to be useful, and to a lesser degree, to be easy to use. Age did not have a significant effect on perceptions of usefulness and ease of use of a robot for the home, when technology and robot experience were accounted for. This again suggests that older adults may have as positive views about such robots as younger adults. Both age groups may expect a robot in their home to be productive but may be less sure about how easy it would be to have the robot perform the tasks they would want it to perform. Additionally, individuals' experiences with technology may affect how useful and easy to use they expect a robot to be, with more experience associated with greater expectations of usefulness and ease of use of a robot for the home.

As with any new technology, there is a question about whether individuals will accept the technology. Participants in the questionnaire indicated moderately-high attitudinal acceptance of a robot for the home, but lower intentional acceptance. So whereas individuals may have positive attitudes towards a robot for the home, they may be uncertain about whether or not they would actually purchase one for themselves. The majority of participants, however, still indicated that they would recommend the robot they imagined in their home to others, such as family and friends.

Participants' expectations about the usefulness and ease of use of a robot for their home were predictive of their attitudinal and intentional acceptance of the robot. Although it was hypothesized that additional prototypical characteristics of a robot for the home would add to the predictive power of these TAM-related variables, this effect was not found. The lack of additional variance explained by the robot characteristic factors were likely because socially-oriented trait scores and, particularly, productive-oriented trait scores were highly correlated with usefulness and ease of use. Still, the results are important because they demonstrate that individuals may accept a robot in their home if they perceive it as useful and not very difficult to use.

Aside from uncovering the expectations that participants have about home-based robots, the questionnaire also addressed the types of tasks that individuals would let a robot perform in their home. Participants were presented with 15 possible robot tasks and asked to indicate how willing they would be to let a robot perform those tasks. The results suggested that individuals may be more willing to have robots perform infrequent, but critical tasks such as emergency notification, than service tasks, and may be least willing to have robots perform interactive tasks. Still, the majority of participants indicated interest in having robots perform all three types of tasks. The results suggest that individuals may be more accepting of robots which provide many benefits, particularly in terms of security and safety, but the amount of interaction that is required with the robot is minimal. This may be particularly true for older adults, who indicated more willingness than younger adults to have robots perform critical monitoring tasks that would require little interaction between the robot and the human. This is likely related to a greater number of older adults than younger adults indicating living by themselves.

The importance of having a robot that is useful and benefits the user was also supported through the scenario question presented to participants. This question was about whether participants would trust a robot to take care of them in their home or participants would rather move to a care facility. The majority of participants indicated that they would rather stay in their own home under the care of a robot than have to move to a care facility. The result is similar to other studies which found the individuals are willing to put technology in their home if it means they can retain their independence (e.g., Melenhorst, Rogers, & Bouwhuis, 2006). Thus the benefit of having a caretaker robot, that is being able to stay in one's own home, for the most part outweighed participants' concerns about such a robot. Participants did, however, indicate that they would need a lot of evidence that the robot was reliable, intelligent, and knowledgeable enough to take care of them in this situation.

The final informative result of the questionnaire study was that nearly 30% of participants indicated that their views or opinions of robots had changed. Largely these changes were about the tasks that robots could perform in the home. Initially participants described robots that performed mundane activities, such as cleaning. Exposure to other types of tasks that robots could perform changed their perceptions about what a robot in the home could be used for. This result may be problematic in that participants' perceptions of a robot in their home had changed due to the survey instrument.

One shortfall of the questionnaire was that although it provided evidence about *how* participants think about robots for the home, it could not explain *why* they had these expectations. For example, almost all variance in participants' scores on the three robot characteristic factors remained unexplained. Technology experience had a significant relationship to performance-oriented trait scores, but even this relationship was weak. It is important to remember, however, that the questionnaire was largely an exploratory study into people's existing expectations of and attitudes towards home-based robots. In this regard, the questionnaire was successful in that it laid out ways that individuals imagine a robot in their home. The questionnaire also provided evidence that individuals are willing to have a robot in their home if it provides clear benefits to them and does not require a lot of effort on their part to use.

CHAPTER 4: INTERVIEW METHOD

Participants

A total of 36 individuals were interviewed about their expectations of and attitudes toward a robot in their home. Three age groups were represented: younger adults (aged 19-26, M = 21.5, SD = 2.20), younger-older adults (aged 65-75, M = 69.5, SD = 2.84), and older-older adults (aged 77-85, M = 80.2, SD = 2.36). There were 12 participants in each age group, with each group having an equal number of male and female participants. Participants of all three age groups were recruited via phone from an age-targeted database of individuals in the Atlanta Metropolitan Area who had indicated interest in participating in studies. They were compensated with $25 at the conclusion of the study.

The demographic characteristics of participants are presented in Table 31. Some characteristics should be noted. First of all participants were, overall, highly educated with approximately 89% of participants reporting at least some college education. A chi-square test indicated no significant difference in education level across the three age groups, χ^2 (10, N = 36) = 7.77, p = .65. A majority of participants, 78%, indicated living independently in a house, apartment, or condominium. Older adults residing in assisted living centers and nursing homes were not included in this sample. In terms of occupational status, the majority of younger adults (75%) were students, whereas the majority of younger-older adults and older-older adults were retired (83% and 67%, respectively). There was no significant difference in the yearly income levels of participants in the three age groups as indicated by a linear-by-linear chi-square test on four condensed income levels, χ^2 (6, N = 24) = 2.11, p = .15. In terms of ethnicity, 75% of participant considering themselves White/Caucasian. Finally, whereas the majority of younger adults indicated being single (92%), older adults primarily indicated being married (54%), divorced (17%), or widowed (21%).

Table 31. *Demographic Characteristics of Interview Participants*

	N			
Age Group	***Younger Adults*** (19-26 yrs)	***Younger- Older Adults*** (65-75 yrs)	***Older-Younger Adults*** (77-85 yrs)	***Total N = 36***
Highest Level of Education				
Less than high school	0	1	1	2
High school/GED	0	1	1	2
Some college/Associate's	6	3	3	12
Bachelor's degree	5	4	2	11
Master's degree/post-grad	1	2	3	6
Doctoral degree	0	1	2	3
Hispanic/Latino				
Yes	1	1	0	2
No	11	11	12	34
Race				
Asian	2	0	0	2
Black/African American	0	2	2	4
Multiracial	1	0	0	1
White/Caucasian	8	10	9	27
No Primary Group	1	0	0	1
Marital Status				
Single	11	2	0	13
Married	0	6	7	13
Separated	1	0	0	1
Divorced	0	2	2	4
Widowed	0	2	3	5

Table 29 (continued)

Age Group	*Younger Adults*	*Young-Older Adults*	*Older-Older Adults*	*Total*
Housing Type				
Residence hall/dorm	2	0	0	2
House/apartment/condo	8	11	9	28
Independent senior housing	0	1	2	3
Relative's home	1	0	0	1
Other	1	0	0	1
Occupational Status				
Work full time	3	1	0	4
Work part time	0	1	0	1
Student	9	0	0	9
Homemaker	0	0	2	2
Retired	0	10	8	18
Volunteer work	0	0	1	1
Other	0	0	1	1
Yearly Income				
Less than $30,000	5	2	2	9
$30,000-$59,999	1	5	0	6
$60,000-$99,999	2	3	2	7
$100,000 or more	0	1	1	2
English Primary Language				
Yes	9	12	12	33
No	3	0	0	3

Materials

Demographics and Health Questionnaire

Participants' demographic and health information were collected via a questionnaire based on an extended version of that used in the survey study. See Appendix P for the complete questionnaire.

Structured Interview

The structured interview script was developed to understand younger and older adults' perceptions about robots in general, and, more specifically, expectations of and attitudes towards a robot in their home. There were six overarching questions that the script was designed to address:

1) How do participants define 'robot'?
2) What tasks do participants expect a robot in their home to perform and what are the defining characteristics of those tasks?
3) What do participants expect a robot in their home to look like and why?
4) What are participants' attitudes toward a robot in their home?
5) What are participants' expectations of and attitudes toward robots performing entertainment-, heath-, and security-related tasks?
6) What are the variables that influence whether or not participants would be accepting of a robot for their home?

The interview consisted of twelve major question categories, with some questions having multiple sub-parts. There were a total of 41 questions that participants were asked. The full interview script is available in Appendix Q. The following is a short summary of the questions that were asked of participants and the reasoning behind those questions.

The interview script included a short introduction to the topic of the interview and instructions to participants. This was followed by three questions to address how participants defined 'robot'. These questions included participants providing their own definition, indicating how they came up with their definition, and indicating how they thought robots were different (if at all) from other types of technology. The last question was particularly important because it would show what participants thought would be the distinguishing characteristics of robots.

The next interview question instructed participants to describe their home as if they were giving a short tour. This question was included to have participants start visualizing their own homes and make it easier for them to picture a robot in their home. This question was not included in the analysis of the interview.

The subsequent part of the interview instructed participants to imagine a robot being put in their home. They were told to picture what the robot would look like, behave like, and do in their home. They were also instructed to imagine how they would interact with the robot, if at all. Participants were given a minute to visualize a robot in their home.

The first parts of the interview script, following visualization of a robot in the home, included questions about the tasks that this robot would do. These questions were about types of tasks why the participant would want the robot to do those tasks. Additionally, there were questions about how participants imagined the robot would know how to do the tasks, what they imagined their own roles would be in those tasks, their comfort with letting a robot make decisions about tasks on its own, and what they imagined the robot would do when it was done with its tasks. These questions were designed to elicit participants' perceptions about the role of a robot in the home as well as their own role in relation to the robot.

The next questions on the interview addressed the appearance of the robot that participants imagined in their home. This included a general question about appearance with several follow-up questions if the participants did not mention certain characteristics in their original response (e.g., What is the size of the robot?). The general question about appearance was followed with a question about why participants thought the robot would look the way they had described.

The following ten questions in the interview were created to address participants' attitudes toward a robot in their home indirectly. This indirect approach was used because it was felt that it would be difficult for participants to verbalize their attitudes. For example, the questions about what the robot would do when guests were over and how other individuals would use the robot were designed to address social attitudes towards the robot and views about whether a robot would be personalized for different users, respectively.

The next set of questions in the interview were included to expose participants to categories of tasks that a robot could perform in the home and to see their expectations of and attitudes towards a robot performing those tasks. Three task domains were chosen:

entertainment, health, and security. These were selected because of varying levels of criticality and presumed levels of interaction with the user. The three areas were left abstract (e.g., “health” was not defined as medication management) to let participants form their own perceptions about what a robot in such domains could do. The script instructed participants to first imagine a robot for entertainment, secondly for health-related activities, and lastly for security. Each task domain was followed by four questions about what a robot in that domain would do, what it would look like, how it would know what to do, and what was the overall opinion participants had about that robot. If a participant had mentioned one or more of the task domains in their initial description of a robot in their home, they would not be asked about that domain again.

The final questions in the interview were about the acceptance of a robot in the home. These questions were about the characteristics that would decrease or increase acceptance of such a robot. Additionally there was a question about whether participants imagined they would need to change their lifestyle for a robot in the home. The interview script concluded with a question about whether participants felt that their opinion or view of robots had changed and whether they wanted to mention anything else about robots.

Exit Interview

The exit interview was created to access whether participants had ever thought about a robot in their home before the interview, determine how difficult it was for them to imagine a robot in their home, and uncover the strategies they used to imagine a robot in their home. The first part had participants indicate yes or no to the question of whether they had previously thought about a robot in their home. The next part of the exit interview asked participants to indicate the ease or difficulty they experienced in imaging a robot in their home on a scale from 1 = “difficult to imagine” to 5 = “easy to imagine”. The final part of the exit interview asked participants to indicate what they did to imagine a robot in their home, by selecting among any number of choices including thinking about an existing product, fictional robot, or non-fictional robot. For some choices, participants were instructed to write specifically what they were thinking about and the source from which it came. The full exit interview is presented in Appendix R.

Technology Experience and Robot Experience

The technology experience and robot experience were assessed using Part A and Part B of Section III in the robot questionnaire described earlier in the paper. There were 20 items asking participants about their experience with technology over the past year and six items about their experience with available consumer robots.

Procedure

Individuals from the Human Factors and Aging Laboratory Database were contacted if they were within one of the three targeted age groups for the study. They were informed about the purpose of the study and scheduled if they indicated interest in participating. Participants were mailed more information about the study and were also sent the demographics and health questionnaire for them to fill out and bring with them at their scheduled time.

Participants were interviewed individually in a private room in the psychology building on the Georgia Institute of Technology campus. Participants were first welcomed and then given informed consent forms. Once informed consent was obtained, the researcher read the introduction on the interview script and then asked participants if they had any questions. After all participants' questions were answered, the researcher turned on the digital voice recorder and began the interview. The researcher attempted to retain neutrality and avoid bias by limiting verbal and non-verbal cues that would suggest how the participants should answer the questions in the interview. A single researcher conducted all interviews with participants.

At the conclusion of the interview, the researcher turned off the digital voice recorder. Participants were given the exit interview questions followed by the technology experience and robot experience questionnaire.

At the close of the session, participants were compensated and thanked. Audio files from the interviews were uploaded to a computer and sent to a third-party transcription company for verbatim transcription.

CHAPTER 5: INTERVIEW ANALYSIS, RESULTS, AND DISCUSSION

Reported Health

Along with demographic information, participants answered questions about their current health. The means and standard deviations of participants' answers to questions about general health, health compared to others in age group, satisfaction with health, and how much their health limits activities they want to do are presented in Table 32. In general, participants indicated "good" to "excellent" health and indicated their health getting in the way of what they want to do "never" to "seldom".

An overall-health scale of the four items was created by first reverse-scoring the limits in activities responses and then by taking the mean of each participant's responses to this and the three other items. Younger adults had a mean overall-health score of 4.14 (SD = .53), younger-older adults a mean score of 3.63 (SD = 1.10), and older-older adults a mean score of 4.29 (SD = .66). The internal consistency reliability of the scale was acceptable with a moderately-high Cronbach's alpha, $\alpha = .88$. The scree plot from a principal components analysis indicated a single component was appropriate for the scale. An ANOVA with age group (younger, younger-older, and older-older) as the independent variable and overall-health score as the dependent variable was performed. The analysis indicated no significant effect of age group on perceived overall health, $F(2,33) = 2.29$, $p = .12$. Additional health information about participants is available in Table 33 and Table 34. Reported limits in activities due to health are presented in Table 33; reported health conditions are presented in Table 34.

Table 32. *Reported Health of Interview Participants*

	Group	Mean	Std. Dev
Self-reported general health (1 = poor to 5 = excellent)	Younger adults	4.17	0.72
	Younger-older adults	3.50	1.17
	Older-older adults	4.00	0.95
Health compared to others in age group (1 = poor to 5 = excellent)	Younger adults	4.08	0.67
	Younger-older adults	3.58	1.38
	Older-older adults	4.17	1.03
Satisfaction with health (1 = not at all to 5 = extremely satisfied)	Younger adults	4.08	0.79
	Younger-older adults	3.67	1.23
	Older-older adults	4.67	0.49
"How often do health problems stand in the way of doing the things you want to do?" (1 = never to 5 = always)	Younger adults	1.75	0.62
	Younger-older adults	2.25	1.06
	Older-older adults	1.67	0.78

Table 33. *Reported Limits in Activities Due to Health of Interview Participants*

Activity	**Group**	**N** Not Limited at All	Limited a Little	Limited a Lot	**Linear-by-Linear χ^2**	***p***
Bathing/ dressing	Younger adults	12	0	0	(1, *N* = 36) = 0.00	1.00
	Younger-older adults	10	2	0		
	Older-older adults	12	0	0		
Bending/ kneeling/ stooping	Younger adults	12	0	0	(1, *N* = 36) = 2.67	0.10
	Younger-older adults	8	3	1		
	Older-older adults	8	4	0		
Climbing flight of stairs	Younger adults	12	0	0	(1, *N* = 36) = 1.64	0.20
	Younger-older adults	10	2	0		
	Older-older adults	10	2	0		
Climbing several flights of stairs	Younger adults	12	0	0	(1, *N* = 36) = 3.04	0.08
	Younger-older adults	6	5	1		
	Older-older adults	8	3	1		
Lifting or carrying groceries	Younger adults	12	0	0	(1, *N* = 34) = 1.20	0.27
	Younger-older adults	9	2	1		
	Older-older adults	8	2	0		
Moderate household activities	Younger adults	12	0	0	(1, *N* = 36) = 1.36	0.24
	Younger-older adults	9	3	0		
	Older-older adults	10	2	0		
Vigorous activities	Younger adults	11	1	0	(1, *N* = 36) = 5.69	0.02**
	Younger-older adults	2	3	7		
	Older-older adults	4	5	3		
Walking more than a mile	Younger adults	11	1	0	(1, *N* = 36) = 1.94	0.16
	Younger-older adults	7	4	1		
	Older-older adults	8	3	1		
Walking one block	Younger adults	12	0	0	(1, *N* = 36) = 0.77	0.38
	Younger-older adults	11	1	0		
	Older-older adults	11	1	0		
Walking several blocks	Younger adults	12	0	0	(2, *N* = 36) = 0.76	0.38
	Younger-older adults	8	3	1		
	Older-older adults	10	2	0		

** significant age differences at .01 level

Table 34. *Reported Medical Conditions of Interview Participants*

Medical conditions	Group	N Never	Now	In Lifetime	Pearson χ^2	*p*
Arthritis	Younger adults	12	0	0	(4, *N* = 35) = 8.64	0.07
	Younger-older adults	6	5	1		
	Older-older adults	8	3	0		
Asthma/ Bronchitis	Younger adults	8	1	3	(2, *N* = 34) = 4.20	0.38
	Younger-older adults	6	2	3		
	Older-older adults	10	0	1		
Cancer	Younger adults	12	0	0	(2, *N* = 35) = 1.11	0.57
	Younger-older adults	10	0	1		
	Older-older adults	11	0	1		
Diabetes	Younger adults	12	0	0	(2, *N* = 36) = 6.74	0.03*
	Younger-older adults	7	5	0		
	Older-older adults	10	2	0		
Epilepsy	Younger adults	12	0	0		
	Younger-older adults	11	0	0		
	Older-older adults	12	0	0		
Heart disease	Younger adults	12	0	0	(2, *N* = 35) = 3.78	0.44
	Younger-older adults	8	1	2		
	Older-older adults	10	1	1		
Hearing impairment	Younger adults	12	0	0	(2, *N* = 35) = 6.40	0.04*
	Younger-older adults	7	4	0		
	Older-older adults	7	5	0		
Hypertension	Younger adults	12	0	0	(2, *N* = 35) = 10.20	0.04*
	Younger-older adults	7	5	0		
	Older-older adults	5	5	1		
Stroke	Younger adults	11	1	0	(2, *N* = 35) = 3.89	0.42
	Younger-older adults	11	0	0		
	Older-older adults	11	0	1		
Vision Impairment	Younger adults	10	1	0	(2, *N* = 34) = 9.44	.05
	Younger-older adults	5	6	0		
	Older-older adults	6	4	2		

* significant age differences at .05 level

Technology and Robot Experience

Technology Experience

Participants were each given technology experience scores based on the mean of their responses to18 items in the technology experience questionnaire. For this scale, a score of 1.0 would indicate no experience and a score of 5.0 would indicate daily experience with the 18 technological items in the scale. Because home medical device and non-digital camera were removed from the scale in the questionnaire study, these were not included in this study as well. Cronbach's alpha for the scale was moderate but acceptable, $\alpha = .717$. The scree plot from a principal components analysis indicated a single component was appropriate for the scale. An ANOVA, with age group (younger, younger-older, and older-older) as the independent variable and technology experience scores as the dependent variable was performed. The analysis indicated a significant effect of age on technology experience, $F(2, 33) = 11.43$, $p < .001$, $\eta_p^2 = .41$. Contrasts indicated that that younger adults ($M = 4.032$, $SD = .37$) had significantly higher technology experience scores than younger-older adults ($M = 3.40$, $SD = .35$), $p = .004$, and older-older adults ($M = 3.08$, $SD = .69$), $p < .001$. There was no significant difference in technology experience scores between younger-older and older-older adults, $p = .12$.

Robot Experience

The internal consistency reliability of the six items in the robot experience scale was assessed using Cronbach's alpha and found to be unacceptably low, $\alpha = .67$. An item-by-item analysis indicated that the robot security guard item did not correlate well with the other items on the scale. With this item remove, Cronbach's alpha was found to be acceptable, $\alpha = .75$. The scree plot from a principal components analysis indicated a single component was appropriate for the scale. For the robot experience scale, a score of 1.0 would indicate no experience and a score of 5.0 would indicate extensive experience with (i.e., ownership and use of) the five robot items in the scale. The mean score on the robot experience scale was 2.37 for younger adults ($SD = .71$), 1.97 for younger-older adults ($SD = .74$), and 1.85 for older-older adults ($SD = .69$).

An ANOVA, with age group (younger, younger-older, and older-older) as the independent variable and robot experience scores as the dependent variable was performed. The analysis indicated a non-significant effect of age on robot experiences scores, $F(2, 33) = 1.72$, $p = .20$.

Interview Coding and Analysis

After interviews were transcribed, a coding scheme was developed to analyze participants' answers. The development of the coding scheme combined top-down and bottom-up approaches. A top-down approach was used to examine human-like and machine-like characteristics of participants' envisioned home-based robots and develop coding dimensions based on these distinctions. A bottom-up approach, conducted by examining and categorizing all participants' answers across all questions, was used to ensure that all commonalities in answers were accounted for in the coding scheme. The resulting coding scheme included 244 dimensions on which participants' interviews were coded on. An outline of the coding scheme is available in Appendix S. The complete coding scheme given to coders included definitions of each dimension as well as example quotes for each category in the scheme. Answers to specific questions were coded only on their respective dimensions. For example, the first question ("In your own words, what is a robot?") was coded only on dimensions 1.1-1.4 of the coding scheme. If participants later provided an alternative definition, this was not coded on those same dimensions.

Two researchers, a primary coder and a secondary coder, coded transcripts using text analysis software MAXQDA 2007. Three interviews, randomly selected from each of the three age groups (younger adults, younger-older adults, and older-older adults) were coded by both coders and an additional researcher to measure inter-rater reliability. The percent agreement between the secondary coder and the primary coder and between the additional researcher and the primary coder were both 90%. The primary and secondary coders reviewed disparate codings and modified the coding scheme for clarification. The remaining interviews were analyzed by either the primary or secondary coders, with 18 interviews assigned to the primary coder and 15 to the secondary coder. Each coder received an equal number of interviews to analyze from the three age groups. The specific transcripts that each coder was responsible for were randomly chosen from within the age groups.

The number of participant answers that were coded for each dimension in the coding scheme is presented in Appendix T. The following section highlights important and interesting findings from the interview. Readers should refer to Appendix T for complete information about the frequency of participants' answers.

Interview Results

Robot Definition

Participants were asked to give their own definition of a 'robot'. Their answers were coded along four dimensions: 1) description of robots as mechanical or electronic machines, 2) human-likeness of robots, 3) function of robots, and 4) how robots are controlled.

The majority of participants, 86%, explicitly stated in their definition of robots that robots are devices or machines, with 44% stating more specifically that robots are mechanical machines or devices (e.g., "A robot is a mechanical device"). Comparatively, only 22% of participants mentioned human-likeness (or unlikeness) in their definition of robots; whether it be likeness in terms of how the robot looks and acts (e.g., "is like a human that does human functions or made to be like a human") or statements about how a robot is and is not like a human (e.g., "Anything that can function like a human but doesn't have the characteristics of reasoning").

Function was mentioned by 72% of participants in their definition of robots. The function of robots as replacing humans was the most common statement (31%, e.g., "could replace humans in certain areas"), followed by the function of doing whatever humans want them to do (19%, e.g., “will do functions for whoever is directing it”). Younger adults accounted for five out of seven of the participants who stated that the function of a robot is to do whatever humans want them to do.

In terms of control, 25% of participants included some mention of how robots are controlled in their definition of robots. A robot as being something that is programmed was mentioned by 22% of participants (e.g., “programmed by humans”), whereas only 6% of participants included in their definition that a robot is controlled directly by humans (e.g., “given prompting or using some kind of remote”).

Source of Definition

After providing their definition of robot, participants were asked how they came up with their definition. Participants’ answers were coded on five source dimensions: 1) TV, 2) movies, 3) print media, 4) experience, and 5) imagination/thinking. Multiple codings for an answer were given if a participant stated more than once source. The percent of participants’ responses, out of all responses, that included statements about the five source dimensions is presented in Figure 13. As seen in the figure, there was no one source that was stated overwhelmingly more than another source, although visual media together (TV, movies, and print media) accounted for 53% of responses.

Participants mentioned various influences on their definition of robot within each source category. Within each media category, participants stated both fictional (e.g., “seeing something about robotics on television…from the cartoon where they have robots doing work”) and non-fictional sources (e.g., “I’m interested in science and technology so I've read articles on [robots]"). When participants mentioned experience with robots, 73% mentioned having firsthand experience with them (e.g., "from past experience, seeing a robot and how it functions"). Five participants explicitly mentioned having experience with consumer robots (e.g., "I've seen the little vacuum cleaner type robots") and six participants explicitly mentioned having experience with robots in factories or manufacturing plants (e.g., "I've been exposed to robotics in manufacturing and in processing"). When participants mentioned that the source of their definition for robots came from their imagination or from thinking about robots in general, half mentioned that they imagined how robots work or about the tasks they perform (e.g., "Picturing what a robot should do purpose wise"). To summarize, the self-reported sources of participants' definitions of robots were many, rather than from any one source and came from media, personal and second-hand experiences with robots, and participants' imaginations.

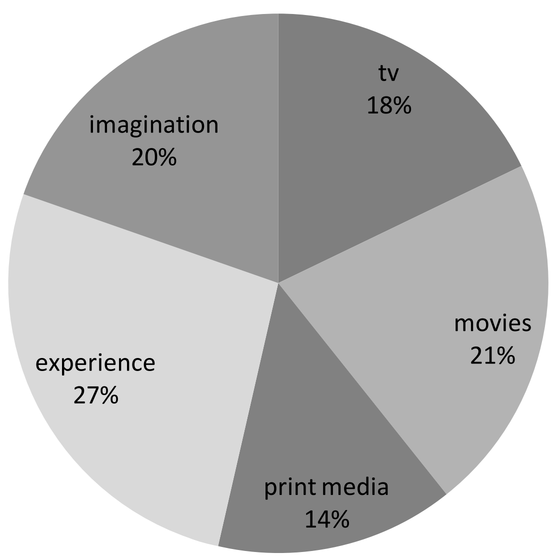

Figure 13. Percent of participant's responses about the source of their robot definition.

Differences between Robots and Other Types of Technology

Participants were asked what they felt were the differences, if any, between robots and other types of technology. A majority of participants, 69% explicitly stated that there were differences between robots and other types of technology, compared to 11% who explicitly stated that there were no differences between the two (e.g., "I kind of lump all technologies together, including robotics"). The individuals who said that there were no differences between robots and other types of technology were all older adults.

When participants specified the differences between robots and other types of technology, they most often mentioned task differences and/or control differences, with 42% of participants mentioning at least one task difference and 42% at least one control difference between robots and other types of technology. The task differences included more "human" tasks (e.g., "It can perform something that a person would normally do but not necessarily something that a piece of software could do"), more tasks in general (e.g., "programmed to do more things"), more complex tasks (e.g., "more complicated task"), and more personalized tasks (e.g., "It's more personalized to do a task"). When participants mentioned differences in how robots were controlled compared to how other technology was controlled, they mainly mentioned programming (36% of participants) rather than direct-human control differences (6% of participants). In terms of programming, participants replied that robots were more programmed (e.g., "it is programmed to do more things"), more pre-programmed or automatic (e.g., "You hit a go button and it just functions"), or more user-programmed (e.g., "It does things automatically that you have preset it to do"). Thus, participants largely differentiated robots from other types of technology by the quality and quantity of tasks that robots perform and the programming of robots to know how to do those tasks.

Three participants mentioned that a robot is more human-like in appearance or function than other types of technology. Although few participants mentioned human-likeness, quotes from these individuals reveal a close association between human characteristics and robots. For example a younger adult female, when asked how a robot is different from other types of technology, replied:

> I just think to a certain extent if you've got something that looks somewhat human and does human functions it's different from a dishwasher. That is just a dishwasher. If you've got something that does functions that are more human and can talk to you and respond or anything like that it's different in the sense that it…It is almost just a little… It's a higher technology and it's one of those things where some people are uncomfortable with because it can be so human like.

So although few participants mentioned human-likeness when referring to robot-technology differences, participants who did mention this saw a strong connection between "humanness" and "robotness".

Additional differences between robots and other types of technology mentioned by participants included mobility or physical presence of robots and intelligence of robots, with 14% of participants mentioning each. References to the mobility of robots or their physical presence included quotes such as: "For one thing, it's moveable. [A] computer, you can't move it unless someone moves it". Participants who mentioned intelligence as a difference between robots and other technology thought that robots were more intelligent. For example one participant said: "I would think that a robot has some ability for thinking." For these participants the notion of robots moving in their environments and thinking for themselves, distinguished them from other types of technology.

What did participants categorize as "other types of technology"? Sixteen participants explicitly mentioned technology that they believed were not robots. The most common "other" technology was a computer, mentioned by five participants. Other non-robot technology included software, a CD, television set, dishwasher, vacuum cleaner, palm pilot, factory machine, alarm clock, telephone, microwave, and cell phone.

Robot Tasks

The first thing that participants were asked after being instructed to imagine a robot in their home was to describe the types of tasks that the robot would do. There were eight task categories that participants mentioned: 1) aiding or assisting, 2) cleaning or organizing, 3) cooking, 4) home repair or home maintenance, 5) working with other machines or appliances, 6) taking care of pets, 7) providing security, and 8) serving (i.e., like a butler). No participants mentioned highly interactive robot tasks such as the robot providing company or conversation.

The most often mentioned tasks that participants imagined robots performing in their home were cleaning and/or organizing-type tasks, with 97% of participants mentioning at least one type of this task. This included tasks such as washing dishes, vacuuming, and doing laundry. The three following quotes are representative of the participants' desires to have robots in their home clean and organize for them:

- “Clean, mostly just clean the house, dust, vacuum, (and) clean the bathroom.” – 67 yr old female
- “Mundane tasks such as cleaning, preparing things for you. Organizing things for you, cleaning up.” – 24 yr old male
- “The first [task] I thought of was cleaning. I don’t clean. My generation, my wife took care of the house and I took care of the income. Never the twain met. Cleaning.” – 81 yr old male

Of the participants who imagined their robot performing cleaning or organizing tasks, 83% of them either exclusively mentioned these tasks or mentioned them before mentioning any other types of tasks. Thus, not only were cleaning/organizing tasks the most frequently mentioned tasks, they were also the most first-mentioned tasks.

Besides cleaning tasks, there were three other tasks categories that were mentioned by several participants: 19% of participants mentioned aiding or assisting tasks (e.g., “help me move different stuff that I can’t [move]”), 19% mentioned home repair or home maintenance tasks (e.g., “maybe doing some general repairs, like painting and moving furniture and the lawn”), and 17% mentioned cooking tasks (e.g., “maybe doing the cooking”). Only older adults mentioned aiding or assisting tasks, whereas participants of all three age groups mentioned home repair/maintenance tasks and cooking tasks.

Reasons for Wanting Robots to Do the Tasks Mentioned

Participants were asked why they wanted a robot in their home to do the tasks that they had mentioned. Their responses fell into three categories of reasons: 1) the tasks are either currently difficult or will be difficult in the future, 2) the tasks are boring or time-consuming, and 3) the tasks are not currently getting done as needed.

The most commonly mentioned reason why participants wanted their robot to do the tasks they had mentioned was because they perceived the tasks as boring or time-consuming, with 72% of participants giving this reason. For example a younger-older adult said she would like her robot to clean “because I get tired of doing [those tasks] over and over”. Generally participants also stated that having a robot perform boring or time-consuming tasks would improve their lives by giving them more free time or time to do the things they want to do. For example, a younger adult participant said: “I think that if a robot does those types of tasks, it adds to the quality of life because those necessarily aren’t the tasks that you enjoy to do every day.” Similarly an older-older adult said he would like a robot to vacuum, wash the dishes, and make the beds “because those are never-ending [tasks]. You have to do them almost every day. A robot would give you more time for leisure. Thus, the majority of participants thought that if a robot took over doing mundane and repetitive tasks, such as cleaning, then they themselves would have more time to do the things they wanted to do. Younger adults were especially likely to state this, with 11 out of 12 younger adult participants mentioning that they wanted robots to perform tasks they perceived as boring and time-consuming.

Another reason given by 22% of participants as to why they would want robots to do the tasks they mentioned in their home was that the tasks are currently difficult for them to do or will be difficult for them to do in the future. Only older adults mentioned these reasons. For instance one 74-year-old female participant said that the reason she would like a robot to perform task requiring reaching and bending is because:

> At this stage of the game I've had two knee replacements and those are working pretty good. I'm not allowed to kneel so that involves a robot doing some reaching tasks. I've had my back fused so I'm a little bit limited in my mobility with my back. That again, involves reaching down. And my hips have some arthritic changes in them and that limits me a little bit.

For this participant, a robot could do the tasks she was currently having difficulty with due to physical limitations. Another 79-year old female wanted a robot to do cleaning tasks because in the future she thought she might have difficulty doing those tasks: "In due time, I may not be so capable and I think a robot could replace some of the tasks that I have been doing". Interestingly, only younger-older adults mentioned that the tasks they would like robots to perform are currently difficult (half of younger-older adults mentioned this), whereas only older-older adults mentioned that the tasks might be difficult for them to do in the future.

Lastly, three participants wanted their robot to do the tasks they had mentioned because those tasks were currently not getting done. For example a 26-year-old female who worked full time said that she would like a robot to clean because: "I don't have time to get them done. I work a lot and it's very easy to have the house end up looking like a disaster because I haven't had time to clean." For this participant, a robot could do the task that she was not able to do because of time constraints.

Task Frequency

Participants were asked how often they would want the robot they imagined in their home to do the tasks they had mentioned. Their responses were coded into six categories: 1) continuously, 2) daily (i.e., at least once a day but not continuously), 3) weekly (i.e., at least once a week but not every day), 4) only when needed (i.e., robot performs tasks only when user needs robot to perform those tasks), 5) both scheduled and on demand (i.e., robot performs task at a set time period or when user instructs it to perform task), and 6) depends on tasks (i.e., robot performs some tasks more frequently than others). The percent of participants who indicated their robot would perform tasks at these different frequencies are presented in the graph in Figure 14.

As seen in the graph in Figure 14, the most common frequency mentioned was daily, with 42% of participants wanting their robot to perform tasks at least once a day (e.g., "…vacuuming every day, once a day. The dishes should be done twice a day"). Several participants responded that the frequency with which their robot would perform task would depend on the particular task, with some tasks performed daily, others weekly, and other less than weekly (e.g., "I'd say for cleaning type things, maybe once a week or once every two weeks and dishes two or three nights a week, and if it was washing the car maybe once a month. Bathroom would be about twice a week…"). For these participants, the robot's schedule would depend on how often those tasks needed to be done or how often they were currently done. The next most often stated frequency of robot tasks was weekly (e.g., “I would think weekly”), followed by only when needed. Fewer participants mentioned that the robot would perform tasks continuously, and none mentioned that the robot would perform tasks less than once a week. In summary, participants were more likely to report wanting their robot to perform tasks regularly, albeit not continuously.

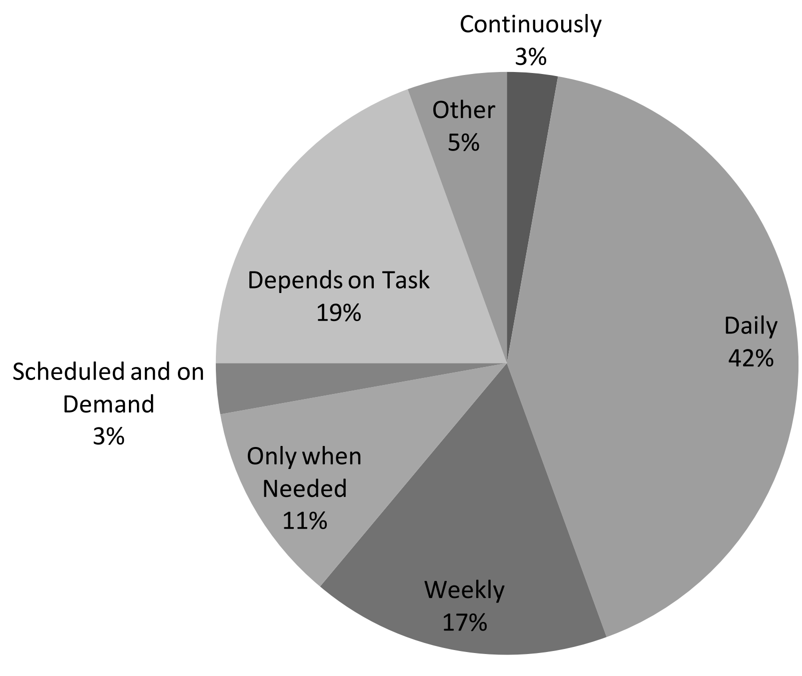

Figure 14. The frequency with which participants would like their robot to perform tasks in their home.

Do Participants want the Robot to Perform Tasks With or Without Them?

Participants were asked if the robot they imagined in their home would do the tasks they had mentioned with or without them. The pie chart in Figure 15 illustrates the distribution of participants' responses. As seen in the figure, the most common response, given by 42% of participants was that the robot would do tasks without them. The next most common responses given by participants were that the robot would perform tasks with them or would sometimes perform tasks with them and sometimes without them, with each response mentioned by 19% of participants. Only older adults, and not younger adults, responded that the robot would have to do tasks with them. Four participants responded that they would perform tasks with the robots initially, but would have robots performs tasks without them later on.

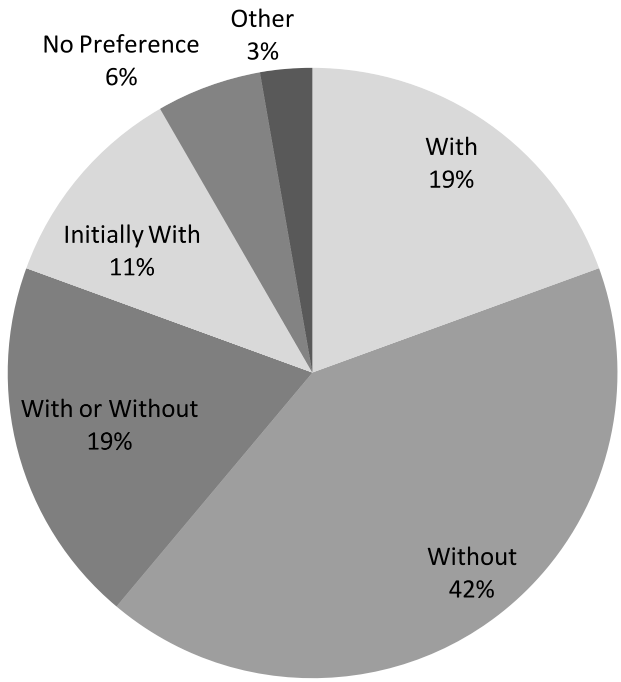

Figure 15. Percent of participants who would want a robot in their home do tasks with or without them.

Participants were asked to explain why they would want the robot in their home to perform tasks with or without them. For participants who said that the robot would perform tasks with them, there were two primary reasons that were cited. The first reason was that the robot needed to be monitored or that they did not trust the robot. For example a 67-year-old female said:

> I would probably want [a robot] to do it with me because I'm not very technologically advanced so I know you would probably have to program the thing to do what you wanted. I'd rather be there to make sure [the robot was] doing what I wanted him to do, what I thought I had programmed him to do.

This individual did not feel comfortable with her ability to program the robot and have the robot perform tasks on its own. She wanted to be present when the robot was performing tasks to make sure it was doing what she wanted it to do.

Generally, when participants mentioned that they needed to be present when the robot was carrying out tasks, they mentioned a general distrust in technology or at least with new technology. For example a 69-year-old male participant said in response to why he would want the robot to do tasks with him:

> With, because I'm very suspicious. Just this past week, I had the guy from the lawn service come to aerate my grass; and I instructed him specifically not to come except when I was there so that I could walk around behind him and say, you need to do this more or that spot more. I'm not that trustful of technology, even technology that interacts with humans, as his aerator did.

So when participants said that they wanted their robot to do tasks with them, they did not necessarily want to interact with the robot, or for them and the robot do tasks together. Rather, they had apprehension about leaving the robot alone or they wanted to be able to supervise the robot's activities.

The second primary reason that participants gave for why they would want the robot to perform tasks with them was that they needed to be present to command the robot. For example a 77-year old male participant said: "With me because I'd have to direct the robot." Another 82-year old male participant said: "I'd want the robot to do it under my command or my wife's command." For these participants, they needed to be present while the robot was doing tasks, because they needed to direct or command the robot; they did not see a robot as being something that could function automatically.

For participants who said that the robot would perform tasks without them, there were two primary reasons that participants gave. The first reason was that participants felt that they could trust the robot or they did not see a need to be present. For example a 20-year old female said: “I don’t think the robot would need my help. If it was programmed a certain way to do what I want it to do, I don’t think it would need me to be there.” The second primary reason that participants gave for why they would want their robot to do tasks without them was to have more time to do their own activities. For instance a 22-year-old male said:

> I’d like the robot to do the tasks individually…I’d like him to do his own tasks so that I can do other things in the given time. In case I have some tasks to do I can tell the robot to do them and then I can get more leisure, more free time to myself. That’s what always I don’t get, time for myself. If someone can do the chores for me, someone can do the cooking, cleaning, washing, everything for me, then that leaves me a lot of time. Basically I can use that time more often, socialize more, meet more people or just watch some movies or something. I definitely want the robot to do its tasks on its own.

This individual, like several other participants, imagined his robot as a time-saving device and thus did not see a need for doing tasks with the robot.

Location of Person when Robot Performs Tasks

Participants were asked where they would be located when the robot was doing those tasks they had mentioned. Their responses were coded into six categories: 1) away from home, 2) in home (general), 3) in home doing own activities (e.g., in a different room than the robot), 4) in same location as robot (e.g., watching or monitoring robot), 5) either in home or away from home, and 6) initially in home then away from home.

Eight participants indicated that they would be entirely away from their home when their robot was performing tasks. These participants mentioned doing their own activities, both for work (e.g., "probably at work or at school") and for leisure (e.g., "I would like to think I'd be out playing, sailing or something like that. Kayaking. Whatever the things that I do."). Many of these participants mentioned that it would be nice to have to robot be done with its tasks once they got home (e.g., "I'd be at school or I just wouldn't be home, so when I get home everything would be nice and clean. That would be nice."). These participants indicated comfort and convenience in letting the robot carry out tasks on its own while they were away from their home.

Half of the participants indicated that they would be in the home, with another 28% responding that they would be in the home at some point, when their robot were performing tasks. Whereas many of these individuals said that they would be in their home but doing their own activities (e.g., "I'd probably be doing some other tasks of my own; paperwork in my office or other readings"), there were seven participants who responded that they would have to be in the same location as the robot, monitoring the robot's activity. These participants were all older adults. Several of these participants mentioned that they would have to make sure the robot was not doing what it was not supposed to do. For example, a 77-year old male, when asked where he would be while the robot was performing tasks said:

> I would assume watching the thing to make sure that it doesn't go where it's not supposed to go. By that, I mean if the door were open, it doesn't go out and start going down the steps which might break it or get on the lawn or a place where I don't want it to be. I'd like to keep it to a prescribed area which would be the floors of the house.

This individual indicated not feeling comfortable leaving the robot alone or out of his sight. All of the participants who responded that they would be in the same location as the robot while the robot was performing tasks had also said that they would perform tasks "with" the robot, either by monitoring the robot or by commanding the robot, in response to the previous question on the interview, "Would the robot do the tasks you mentioned with or without you?". So although most participants indicated some level of comfort with letting the robot in their home perform tasks on its own, there were several older adults who indicated a suspicion or disbelief that the robot would be able to carry out tasks without constant supervision.

How the Robot Knows What to Do

After participants answered several questions pertaining to the tasks that a robot would perform in their home, they were asked how their robot would know how to perform those tasks. The primary purpose of this question was to examine whether participants imagined their robot would be fully or partially automated or whether they thought that the robot would need to be controlled directly, through input devices on the robot itself (e.g., buttons, keypads, or touch screen), remote control, teaching or training the robot, voice commands, or other means.

The majority of participants, 72%, stated that the robot they imagined in their home would be programmed. Whereas 28% mentioned general programming ("It would be programmed"), making it unclear who was doing the programming, several participants were explicit about whether the robot came programmed (e.g., "pre-programmed") or they would need to program the robot themselves (e.g., "I would program it"), or both. Half of the younger adult participants explicitly said that they would program the robot, whereas there were only two younger-older adults and one older-older adult said this.

Direct human control as the method by which their robot would know what to do was mentioned by 42% of participants. The most commonly mentioned direct control method was voice commands or voice activation (e.g., "I assume you can speak to the robot and it would interpret what you say and do it"), with a quarter of participants mentioning this method. Half of younger-older adults stated that their robot would be controlled by voice commands, whereas only one younger adult and two older-older adults mentioned this method of control. Direct control by input device on the robot, remote control, or teaching/ training the robot, were mentioned by a few participants, but there were no clear patterns in preference for one type of control over another.

Participants' responses to how a robot would know how to do the tasks they had mentioned were also coded for the mentioning of sensors. Sensors were defined as anything that would allow robots to understand or gain knowledge about the environment, for example movement detectors, visual sensors, or auditory sensors. Only two participants, one younger adult and one younger-older adult, mentioned sensors (e.g., "He's going to have some sensors so he can perceive the environment.").

Task Approval

Participants were asked whether the robot in their home could do a task without their approval. The purpose of this question was to ascertain how participants felt about their robot making decisions on its own. The distribution of responses is shown in the pie chart in Figure 16. As seen in the chart, the majority of participants indicated that the robot could not perform tasks without their approval (e.g., "I wouldn't want it to"). Five participants explicitly stated that the robot must only follow commands (e.g., "No….he's going to have to obey what I tell him").

There were eight participants who stated that the robot could perform some tasks without their approval. Specific types of tasks mentioned included those that the robot had done before (e.g., "If it asked to do it before"; "Just extra cleaning") or tasks under certain circumstances (e.g., "…say there's a leak in the cleaning fluid tank and it spilled a bunch of liquid, it could [clean it] without my approval.").

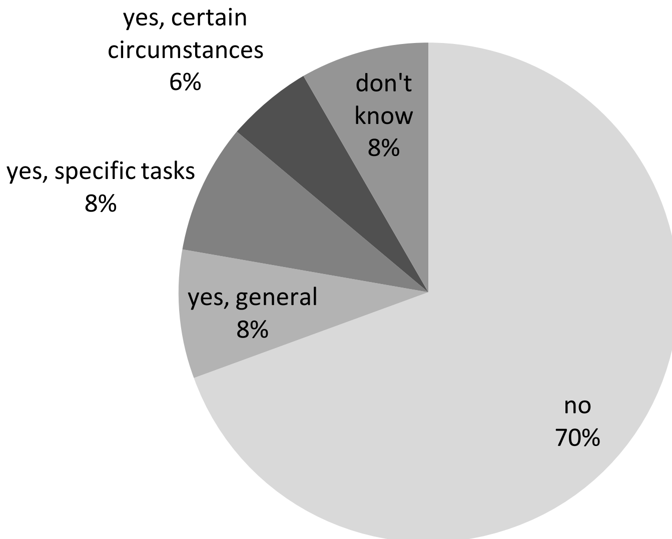

Figure 16. Graph of the percent of participants who indicated whether a robot would be allowed to perform tasks without approval from them.

Robot Activity when Tasks Complete

Participants were asked what they imagined the robot in their home to do when it was done with its tasks. There were four general types of responses: 1) the robot shuts off, 2) the robot stands by, sleeps, or rests, 3) the robot goes or gets put in a specific out-of-the-way location, and 4) the robot recharges. These were not coded as exclusive categories, such that participants' responses could fall under 'robot goes to specific location' and 'robot shuts off', or any other combination of response types.

The most common response was that the robot would go to a specific location when it was done, with 44% of participants stating this. For example a 22-year old male participant said:

> You could probably tell it to go back to wherever it's stored, as long as you don't have a door in its way, like in a closet or something like that. Say you keep it underneath the chest or drawers or something like that, it could just scoot right back under there.

Similarly a 70-year old male participant, when asked what the robot would do when it was done said: "It would park itself someplace. What do you do with the vacuum when it's done?" For many participants, such as these two individuals, the robot would need to go to a nonintrusive location when it was done with its tasks. Common locations that were mentioned by participants included closets and corners.

Another common response that participants gave when asked what the robot would do when it was done was that it would shut off, with 42% of participants stating this. These responses were coded by whether the participant stated that the robot would turn itself off or they would turn the robot off. Twice as many participants stated that the robot would turn off automatically (e.g., "Turn itself off so that it can save energy.") than said that they would turn the robot off (e.g., "I would just have some type of shutdown command and it would just shut down so it doesn't go off and do crazy things without me knowing). So, in general, participants imagined that their robot would turn off automatically and get out of the way when it was done with whatever it was assigned to do; they did not see a need for the robot to be on or visible all the time.

Robot Appearance

Participants were asked to describe what they imagined the robot in their home would look like. Their responses were coded by overall appearance (e.g., human-like or machine-like), height (relative to human height), head and facial features (eyes, mouth, and nose), arms and hands, mobility, material, gender, and interface (buttons, screens, etc.).

Overall appearance. Participants' responses as to what their robot would look like were coded for statements about the robot's overall appearance. The percent of participants who stated that their robot looked human-like, human-like and machine-like, machine-like, like an existing machine, and like an existing fictional character from a media source is presented in the chart in Figure 17. As see in the chart, an equal number of participants stated that their robot was human-like (e.g., "I expect it to look like a human being") as did those that stated that their robot was machine-like (e.g., "Very mechanical. I would not want it to look like a human"). Whereas there were four younger adults and four younger-older adults that stated that they imagined their robot to be human-like, only one older-older adult did so. Additionally, there were five participants who stated that they imagined a robot in their home to have characteristics of both humans and machines. For example one participant described the overall appearance of the robot as "kind of like a human, but without specific details" and another said that the robot "has a body similar to a human…It's very much a machine as opposed to a person"). So whereas some participants imagined their robot as being either very human-like or very mechanical, several participants imagined something in the middle-a device that had an overall appearance between that of a human and that of a machine.

There were a few participants who described the overall appearance of a robot in their home as being similar to existing machines (e.g., "like a vacuum cleaner") or existing fictional characters from media sources (e.g., "Have you ever seen…*The Jetsons*? I guess (it would look like) the robot there, the maid robot"; "like R2-D2."). Only older adults mentioned that the robot they imagined would look like an existing machine in the home.

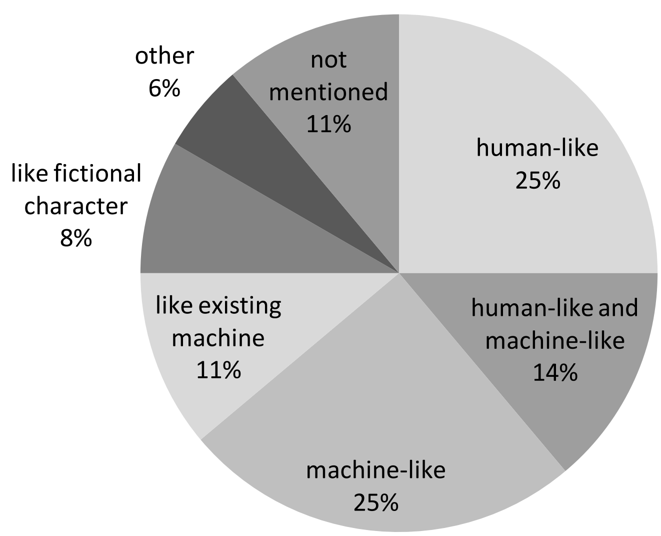

Figure 17. A pie chart of how participants described the overall appearance of a robot in their home.

Robot height. Participants' answers about what a robot in their home would look like were coded for references to the robot's height. The coding categories were designed to specify height relative to a typical adult human: much shorter than a human, slightly shorter than a human, same height as a human, and taller than a human. A category of multiple heights or changing heights was also included. Participants' answers were coded into height categories when they either explicitly gave a height relative to a human (e.g., "the size of a ten-year old") or gave a measurement (e.g., "a foot square").

Most participants who mentioned the robot's height when describing their robot, said that it would be shorter than a human, with 35% of participants stating this. Five participants, all older adults, stated that the robot would be much shorter than a human or less than 3 ft tall; six participants stated that the robot would be slightly shorter than a human, equal to or greater than 3 ft tall but less than 5 ft tall. A quarter of participants, and five out of twelve younger adults, stated that the robot they imagined in their home would be the height of an average human (e.g., "5'5" or about an average human size"). Only one participant stated that robot would be taller than a human of average height. There were also four participants who thought that the height of the robot would change based on the tasks the robot was doing (e.g., "kind of short….when not in use…but then be able to almost like extend to do chores").

Head and facial features. Participants' robot descriptions were coded for whether the robot had a head, face, and facial features - eyes, mouth, and/or nose.

Few participants, 17%, described their robot as having a head or a face, or both. Three participants explicitly stated that the robot did not have a face. For example a 20-year-old female said: "I don't want it to have a face, because that's creepy". There were also relatively few statements about robots having eyes (four participants), a mouth (three participants), and a nose (one participant).

Arms and hands. The descriptions that participants gave of their imagined robots were coded for statements about arms and hands. "Arms" included both human-like and machine-like appendages. Approximately 22% of participants stated that the robot had some sort of arms, with three participants explicitly stating human-like arms and four participants stating machine-like arms (e.g., "appendages that would be thin and long…where they could retract"). The majority of younger adults made some comment about the robot's arms, whereas arms were only mentioned by three older-older adult participants. Only three participants stated that the robot would have hands or fingers (e.g., "two hands"; "It could probably have fingers").

Mobility. Participants' responses to what a robot in their home would look like were coded for statements about mobility, or how the robot moves around the house. Figure 18 shows the distribution of participants' answers about how they imagined their robot to be mobile. As seen in the figure, the most common way that participants described their robot moving around was by wheels, treads, tracks, or other forms of mechanical (non-leg) components (e.g., "rolling ball so it can move at all different angles"). Only four participants mentioned legs exclusively (e.g., "legs…move(s) around like a normal person") and five participants, four of which were younger adults, stated that the robot would have both legs and wheels (e.g., "both legs, and maybe some wheels").

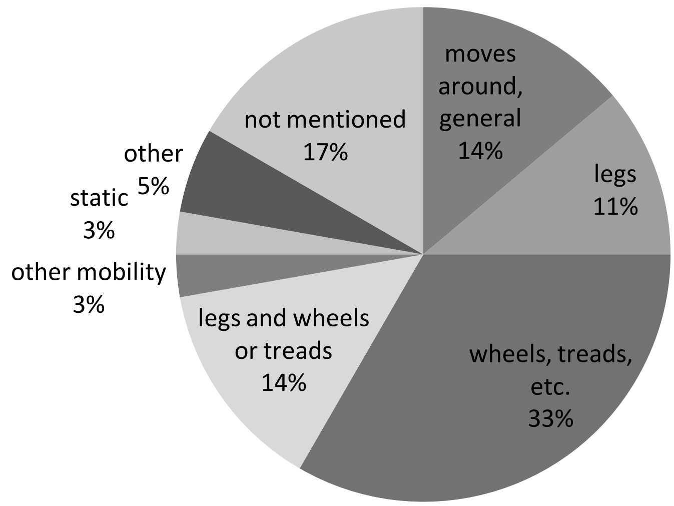

Figure 18. Participants' descriptions of what allows a robot in their home to move around.

Material. Participants' responses to what a robot in the home would look like were coded for references to the material that the robot would be made out of. Approximately 81% of participants stated that the robot would be made out of metal and 47% stated it would be made out of plastic. No other materials were commonly stated by participants in describing their robot.

Gender. Only three participants made reference to the robot's gender (e.g., "I would prefer it to be a feminine robot"), with one participant stating that the gender of the robot did not matter ("It's not distinguished as a male or female.").

Interface. Five participants stated that the robot they imagined had interaction features, such as buttons or screens (e.g., "key pad on his chest"). The majority of participants did not describe anything on the robot that would suggest a physical interface between the person and the robot.

Reason for Appearance

Participants were asked why they thought a robot in their home would look the way they had described it. The most common responses given by participants were that the appearance of the robot matched its functionality (e.g., "to enable it to do the things I need it to"; "because of the space it would be performing its tasks in") and that is simply how they imagined the robot would look like (e.g., "It is what I see when I picture a robot"). These two responses were each made by approximately 31% of participants. Other reasons that participants gave for why they though a robot would look a particular way included how robots are depicted in media sources (e.g., "TV, comic books…and movies") and previous experience with robots (e.g., "Probably because of the designs I've seen in the past"). Five participants said that the look they imagined for their robot would make the robot look friendly and they would have less hesitation in having the robot in their home (e.g., "it would look more friendly, more familiar").

Participants' statements about the overall appearance of their robot were compared to responses about reasons for this appearance. The only pattern that emerged was that eight out of eleven participants who had said that the reason they imagined a robot to look a certain way was because of functionality, had described their robot as having a machine-like or combination of human-like and machine-like appearance. Only one participant had said both functionality and a human-like appearance.

Typical Day with Robot

Participants were asked to describe what they imagined a typical day with a robot in their home would be like. Responses were coded by how the participants described the robot being activated, the tasks that the robot would perform during the day, how the robot would be controlled, where they would be, the activity of the robot if they were away from the home, and the duration of the robot's activity.

In terms of how the robot would be activated, 36% of participants provided information about how the robot would turn on in the morning. Eight participants, and half of all younger adult participants, stated that they would turn the robot on (e.g. "I would turn on the robot…"); five participants stated that the robot would be self-activated (e.g., "It would start at a certain time").

All participants mentioned something about the robot performing tasks on a typical day. Six participants simply stated that the robot would perform task throughout the day, whereas the remainder of participants stated specific tasks that the robot would perform. Once again, clean and organizing type tasks were stated most frequently (e.g., "it starts to clean"; I expect him to do the dishes."), with 75% of participants stating at least one type of cleaning or organizing task that the robot would perform on a typical day. Other less frequently mentioned tasks included cooking, home repair or maintenance, security tasks, and serving tasks. In the original question about tasks that the robot would perform at the beginning of the interview, seven older adults had mentioned aiding or assisting tasks; however no participants mentioned these types of tasks in describing a typical day with the robot. Another difference in tasks between the original task question and the current question was that originally no participants had said that the robot would provide company or conversation; three participants mentioned these types of task when describing their typical day with a robot (e.g., “If it was a talking robot I could imagine me and the robot having a good conversation every day”).

In describing a typical day with the robot in their home, a third of participants mentioned something about how the robot would be controlled or how the robot would know what tasks to do. Again, programming was the most common type of control that participants mentioned (e.g., “I would…program it for whatever I wanted it to do"), although few participants were specific about whether they would do the programming or the robot would be pre-programmed.

Approximately 44% of participants described where they would be on a typical day with the robot in their home. Eleven participants, nine of which were younger adults, stated that they would be away from the home for most of the day. For example a 19-year-old female, in describing her typical day with the robot, said:

> A description? Let’s see. Robot makes breakfast. I eat breakfast. I go to school, take classes, whatever I do. Work, I guess. During that time, I guess the robot cleans the house. Does laundry. All that stuff. Chores that I don’t like to do and then I come home and all that stuff is done and I can relax and do whatever I want.

For this participant, and for most younger-adult participants, a typical day would involve minimal interaction with the robot. For some or most of the day these individuals imagined leaving the robot to do its tasks; nine participants explicitly mentioned that the robot would remain active when they were outside the house, whereas only one participant stated that the robot would be turned off. Older adult participants did not frequently mention where they would be on a typical day with the robot.

The last type of information that was coded from participants' responses about a typical day with the robot in their home was the duration of the robot's activity. Approximately 47% of participants described the robot as being active either continuously or throughout the day whereas 14% stated that the robot would be turned off for at least part of the day (e.g., "It would spend 15 minutes a day doing…clean-up…it would stop and go to wherever its docking point is"; "It would be done with the work in a hour or two"). So whereas there were several participants that imagined the robot would be doing tasks frequently during a typical day, there were a few participants who imagined the robot would only be functioning for a short period of time and would be off for the remainder of the day.

Where Robot is Allowed and Not Allowed in the Home

Participants were asked where the robot would be allowed in their home and if there was anywhere the robot would not be allowed in their home. These were asked as two separate questions and coded separately. Occasionally participants would state that that the robot was allowed everywhere, in response to the first question, but when asked if there was anywhere the robot was not allowed in the home, would state certain locations.

For the first question, ‘Where would the robot be allowed in your home?’, 58% of participants stated that the robot would be allowed everywhere or all locations in the home (e.g., “The robot would have access to all the rooms in the house”). Another 27% of participants indicated that the robot could only be in the rooms or locations where it was performing its tasks (e.g., “Wherever it needs to be to do specific tasks it’s been assigned”; “I think it would pretty much stay in the kitchen, especially if it is just doing dishes”). Thus, there were some participants who imagined the robot in their home being able to go anywhere, there was another group of participants who imagined the robot only being where it needed to be for its assigned tasks.

For the second question, ‘Is there anywhere the robot would not be allowed in your home?’, half of participants stated that there would be no restrictions on where the robot could go. The remaining participants gave a range of places the robot would not have access to. Again, some participants mentioned that the robot would not be allowed in locations it had no reason to be in (e.g., “There’s no reason for it to be in [the bathroom]”). Other participants thought the robot should not be around certain people (e.g., “I wouldn’t want it to go near newborn babies or children”) or certain objects, typically objects of value (e.g., “You may not like it around where you have a china cabinet or some fragile bone china”). A few participants stated that the robot would not be allowed in certain places when they were in those places (e.g., “…he’s not going to be allowed…if I’m taking a shower to come in the shower”; “Probably not in the bathroom while I’m there or in my bedroom when I am sleeping”). The locations that participants stated that they would not want a robot in their home in or near implied certain concerns about the robot: that it would wander around the house, scare or hurt certain people, cause damage to objects, or be intrusive. Still, half of participants indicated comfort with the robot being anywhere in their home.

Frequency of Interaction

Participants were asked how often they would interact with the robot. The chart in Figure 19 shows the percent of participants who stated that they would interact with the robot continuously, at least once a day, at least once a week but not every day, less than once a week, only when needed, as infrequently as possible, or at different frequencies depending on the task. A seen in the figure, the most common responses given by participants were daily (e.g., “on a daily basis”; “three or four times a day”) and only when needed (“When I think of something I want done.”; “Only when necessary.”). So whereas some participants imagined interacting with the robot at least once a day, there were several participants who only imagined interacting with the robot when they needed to give the robot instructions, or rather infrequently.

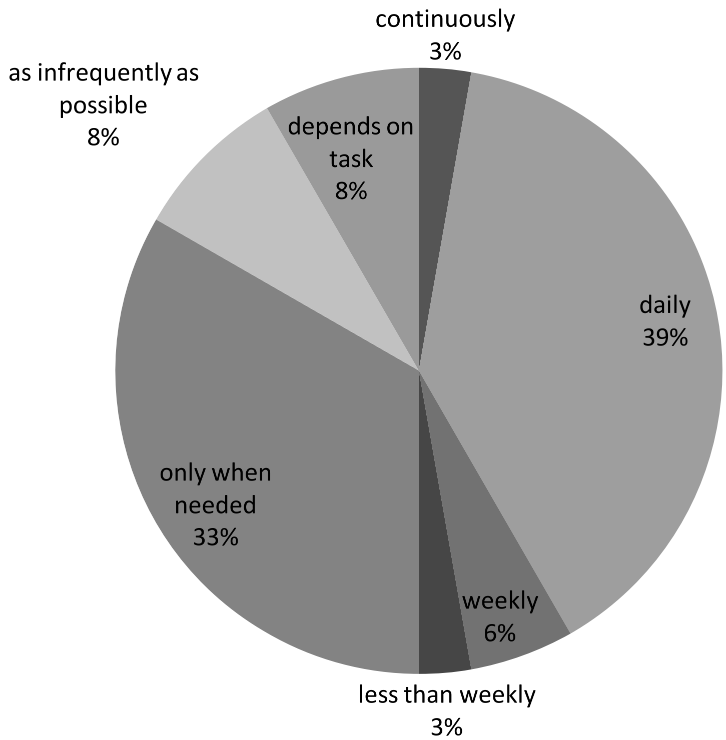

Figure 19. Chart of how frequently participants stated they would imagine interacting with a robot in their home.

Other Users of Robot

For most of the interview, participants talked about how they would use the robot. A question was thus posed to them about whether other people would use the robot and if those other people would use the robot in the same way or in a different way than they would.

The majority of participants, 78%, stated that someone other than themselves would use the robot. Members of the family were the most cited group of people who would also use the robot (e.g. “anyone in the family”). Younger adults also mentioned other people in the household that were not family members, such as roommates. Some participants, 22%, stated that no one else would use the robot (e.g., Probably not. My husband doesn't like anything with buttons."); five out of twelve younger-older adults said this.

For participants who stated that someone else besides them would use the robot, more than half thought that those other people would use the robot in the same way as the they would (e.g., "In the same way."). Four participants thought that the other users of the robot would have the robot perform differ types of tasks based on their need. For example a 20-year-old male participant, when asked if his parents would use the robot in the same way or in a different way than he would, replied:

> I bet he's going to just meet their needs, so basically I'm thinking I'm going to use the robot for my room, just to clean it up. I'm thinking my parents are going to be the ones telling the robots to clean the house and all the other household cleaning he needs to do.

For this participant, the tasks a robot would do would depend on who it is doing them for. Three participants thought that the other people using the robot would interact with it differently or have a different attitude about the robot ("My wife would [use the robot] reluctantly. She really doesn't trust technology….she wouldn't interact with it creatively."). For the most part, however, participants thought that other people would use the robot in a similar or identical way to the way they would.

Robot Activity when Guests Present

Participants were asked what they imagined a robot would do when guests were present in the home. The purpose of this question was to see whether participants imagined the robot's tasks would change based on the situation in the household and whether they would let people outside the household see the robot. Participants' responses were therefore coded by whether the robot would continue doing its typical tasks, whether it would perform different tasks, or whether it would be off or in storage. Additionally, responses were coded by how much interaction the robot would have with guests and whether guests would see the robot or it would be hidden from them.

Approximately 44% of participants stated that the robot would be off or in storage when guests were present. Some of these participants explicitly stated that they would not want the robot to be seen by guests. For example, a 67-year-old female participant responded:

> I would prefer that the robot was not there when I had guests. If somebody rang the bell, of course, it was a neighbor, that would be fine. The robot would be doing what he had to do in his own area. Truthfully, I would not have a guest come when the robot was there. I'd rather it did its tasks when I was alone in the house with my husband.

For this participant, and several others, the robot would be out of the way and "invisible" when other people were over at the house.

Another 44% of participants stated that the robot would perform different types of tasks or be used in a different way when guests were present in the home. One new task type mentioned by several participants was the robot assisting in the background, and importantly, staying out of view of the guests. For example a 23-year-old male:

> Probably help clean dishes if people were over, and that would be the only thing because I wouldn't want too much interaction with it other than help do things around the house. I think the only thing would be just doing dishes or type of cleaning as if they were leaving or after they left, when guests weren't around.

For several participants like this one, the robot would still perform cleaning-type chores but would direct these chores to what was needed when guests were present.

There were some participants that imagined that the robot would perform new tasks that would allow it to be seen by guests. Younger adults in particular stated that the robot would serve guests (e.g., "I would program the robot to get us things, like if I make food it'll bring it over, or go in the fridge and get drinks…"). Other participants imagined that they would show the robot off to the guests. For example a 79-year-old female, when asked what the robot would do when guests are over, said:

> If guests came over, I'd have a surprise for them. When they come in I'd tell them look what I have. Look what Theresa has to show you all. They would just be shocked and wondered how did I do that. They'd probably want to get one too. They would.

For participants like this one the robot would be a topic of conversation for guests. However, the robot would not necessarily interact with guests. Only one participant explicitly stated that the robot would interact with the guests.

Robot Activity When User is Away from Home

Participants were asked about what the robot would do when they were away from the home for two periods of time: a shorter period of a few hours and a longer period of one week. Their answers were coded by whether they stated that the robot would be off, would continue with scheduled tasks, would perform new task, or would be lent out to someone else.

For a shorter period of a few hours the majority of participants, 81%, stated that the robot would be off for part or all of the time. More older adults than younger adults stated that the robot would be off in general (e.g., “Nothing…I’d probably just turn it off”). Younger adults were more likely to say that the robot would be off only if it was done with its assigned tasks (e.g., “If it’s done with its daily chores then it can turn itself off or go to sleep”). Half of participants stated that the robot would continue its tasks, at least part of the time, when they were away from the home for a few hours (e.g., “What it would normally do”). Only two participants said that the robot would perform new tasks while they were away (e.g., “He would be activated as a home security system and he would just stand around until something happened.”).

For the longer period of a week, 72% of participants stated that the robot would be off at least part of the week, if not all of the week. Approximately 31% of participants said the robot would continue doing its scheduled activity for some part of the week, with over half of these participants stating the tasks would be done at a reduced frequency or only when needed. Five participants stated new tasks that the robot would do while they were away. These participants all imagined the robot becoming a security system (e.g., "He should be on a guard mode, so basically protecting the house, making sure there's no thief inside…").

Robot Malfunction

Participants were asked what they would do under two robot malfunction situations: 1) if the robot makes a mistake and 2) if the robot breaks down or stops working. Their answers were coded for whether they would try to fix the robot themselves, have someone else fix the robot or call someone else, try to "teach" the robot, or get rid of the robot or get a new robot.

When asked what they would do if the robot made a mistake, 47% of participants said that they would try to fix the robot themselves (e.g., "try to fix it") and 36% said they would get someone else to fix the robot (e.g., "Take it to the robot store and make them fix it."). Interestingly a quarter of participants, mostly younger adults and younger-older adults would try to teach the robot to avoid making the mistake. For example a 23-year-old male participant, when asked what he would do if the robot made a mistake, said:

> I couldn't get mad 'cause it doesn't have the type of reasoning like a human would, but I would just go over that

> motion if it didn't vacuum correctly or something. I would show it and tell it how to do it again and then hopefully it would learn from that the second time around, me telling it what to do, but I don't think I would get mad 'cause it doesn't have any type of human characteristics or reasoning.

This participant, like several others, imagined that he could show the robot how it had performed something incorrectly and the robot would learn how to perform the task correctly.

When asked what they would do if the robot broke down or stopped working, fewer participants, 19%, stated that they would try to fix the robot themselves compared to those that indicate they would do so if the robot made a mistake. The majority of participants, 86%, responded that they would get someone else to fix the robot. Some participants said that there would be a robot specialist they could call to fix a broken robot (e.g., "Call the robot fixer."). Eight participants stated that if the robot broke down or stopped working that they would get rid of the robot or get replacement robot. No participants stated that they would try to teach or retrain the robot if it broke down or stopped working.

Robot Scenarios

Participants were asked to imagine robots for tasks other than the ones they had previously described: a robot for entertainment, a robot for health-related activities, and a robot for security in the home. For each type of robot they were presented with four questions about what this robot would do in their home, what it would look like, how it would know what to do, and their overall opinion about this type of robot. The following sections describe the results of each series of questions for each of the three types of robots participants were asked to imagine in their home.

Robot for Entertainment

Tasks. After being asked to imagine a robot for entertainment in their home, participants were asked what types of tasks this robot would do. Their responses were coded by whether the tasks stated were forms of direct entertainment, meaning the robot is the entertainment, or forms of indirect entertainment, meaning the robot makes other entertainment devices work or replaces existing devices. To clarify, a robot singing would be coded as direct entertainment, whereas a robot playing a CD or turning on a CD player would be coded as indirect entertainment. A category of 'entertaining' guests, for example serving drinks, and a category of 'don't know ' were also included in the coding scheme.

In stating the types of tasks that a robot for entertainment would do in their home, 61% of participants mentioned some type of direct entertainment. Most of these tasks were one-sided, meaning that the robot would be the active entertainer and the human would be the passive recipient of the entertainment (e.g., "Maybe a robot that could tell jokes; that could play music; that could sing"; "Probably read to me"). Other tasks were two-sided, meaning that the both the robot and the participant would be actively engaged in the entertainment activity. Participants who mentioned interactive activities saw the robot as replacing another person. For example, a 22-year-old male participant, when asked what a robot for entertainment would do, replied:

> … I'd also love the robot if he could play sports with me. I'd love to have company because there are quite a few sports I play and not many people who play all the sports I do. I'd program it to play all the sports that I can. Then I can have my buddy and I don't have to worry about company every again while playing badminton or table tennis or soccer or basketball, whatever it is.

For this participant, a robot for entertainment would be an interactive robot that would replace activities typically performed by another person.

Slightly over half of participants, 52%, stated indirect entertainment tasks that a robot would perform in their home. These tasks included those in which the robot would work or manipulate existing machines (e.g., "… interact with the TV., turn it off and on, change channels) and those in which the robot would replace existing devices (e.g., "Play whichever song or latest DVD that I want him to play."; "Functions like a karaoke machine."). So for many participants, an entertainment robot would perform the same types of activities that current products perform or would simply make existing products easier to use.

Appearance. There were two ways that participants' responses to the appearance of a robot for entertainment were coded: first, by whether they mentioned that the robot looked different (or the same) as the robot they had originally imagined and secondly, by statements about the robot's overall appearance.

In terms of comparisons between the appearance of the entertainment robot and the original robot, 52% of participants made such a comparison. The majority of participants who made a comparison stated that the robots would look the same as the one they had originally imagined (e.g., "I guess it would look like the one I described earlier.").

In terms of overall appearance, there were a similar number of participants who stated that they imagined a robot for entertainment as being human-like (e.g., "…just like a normal person") as those that described it as machine-like (e.g., "I don't think a humanoid type robot would be the one for that…more like a big box."). Five participants, all older adults, stated that a robot for entertainment would look like an existing device or machine (e.g., "It would be almost like a TV).

Control. Participants were asked how a robot used for entertainment would know what to do. Once again programming was the most frequent response, with two-thirds of participants mentioning this as the way that the robot would know how to perform tasks. Although general programming was the most often mentioned type of programming, 31% of participants said that they would program the robot (e.g., "I would probably program it to do those things). Half of participants also stated that the robot for entertainment would be directly controlled. Direct control included input devices on the robot (e.g., "I would press a certain button…and it would do what I want it to do") and voice commands (e.g., "oral orders").

Overall Opinion. Participants' responses to the question about their overall opinion about a robot used for entertainment were coded along three dimensions: 1) explicit statements about their overall attitude towards an entertainment robot, 2) explicit statements about the benefit (or lack of benefit) of an entertainment robot, and 3) explicit statements about the feasibly (or lack thereof) of an entertainment robot.

In respect to overall attitude, 58% of participants made explicit statements about their attitudes toward a robot used for entertainment. Nearly an equal number of participants stated positive attitudes (e.g., "I think it's a cool idea and it'd be nice) as negative attitudes (e.g., "I certainly don't think a robot would be very entertaining") toward this type of robot.

Approximately 22% of participants made statements about the benefits of a robot for entertainment (e.g., "… you wouldn't get lonesome"), whereas 44% of participants made statements about the lack of benefits of a robot for entertainment (e.g., "useless"). Lack of benefits included statements about how the robot would not have as much benefit as the robot originally imagined (e.g., "I would prefer one that did tasks over entertain me") and about how a robot for entertainment would be more of a novelty item (e.g., "…it would be considered an extreme luxury"; "I would find it entertaining the first few times; but after that I would get bored with it").

A few participants, about 19%, made comments about the feasibility of a robot for entertainment. Five participants either did not think a robot could be entertaining or did not know if a robot for entertainment was possible.

Robot for Health-Related Activities

Tasks. When participants were asked to describe what a robot for health-related activities would do in their home, nine categories of responses emerged. These categories included cleaning activities, general care, health monitoring and diagnosis, medication administration, medication reminder, mobility assistance, promotion of diet, promotion of exercise, and promotion of hygiene. Except for promotion of hygiene, there were at least six participants who mentioned tasks that fell into each of these health-related activity categories. The robot performing tasks related to reminding users to take their medication (e.g., "The robot could remind me to take my medication.") was the most commonly mentioned task type, stated by 31% of participants.

Appearance. Participants' statements about the appearance of a robot for health-related activities compared to that of the robot originally described were coded. The most common statement, made by 36% of participants, was that a robot for health related activities would have the same appearance as that of the original robot. Five participants made explicit statements that the robot would have a different appearance, with three participants saying that the robot would look more human-like than the robot they had imagined before.

In terms of statements about the overall appearance of a robot for health-related activities, 31% of participants stated that the robot would be human-like and 17% that it would be machine-like. Six participants imagined the robot would look like an existing device or machine (e.g., "It would look like an alarm clock.").

Control. In response to the question of how a robot for health related activities would know what to do, again participants stated programming most often, with 75% of participants stating this. A quarter of participants stated that the robot would be directly controlled, through input devices on the robot, voice commands, or by other means.

Overall Opinion. The majority of participants, 64%, made statements about their overall attitude towards a robot for health-related activities in their home. Approximately 42% of participants made statement related to positive attitudes (e.g., "It would be wonderful.") and 11% about negative attitudes (e.g., "I would be terrified of it") towards this type of robot.

Several participants (64%) made statements about the benefits of a robot for health-related activities. These statements included benefits to self (e.g., "I think it would be a great thing to have since I live alone") and benefits to others (e.g., "I think it would be wonderful for people that are not capable of doing anything and would really need the help"). Only four participants stated that they did not see much benefit of this type of robot (e.g., "You get more benefit doing it yourself without the robot.") or that the benefit of this type of robot would be less than that of a robot that performed other types of tasks.

Five participants made comments about the feasibility of a robot for health-related activities: one thought this type of robot was feasible and three that did not think or know if this type of robot was feasible.

Robot for Security

Two participants had stated security tasks for the robot they were originally asked to imagine in their home. These two participants, both younger-older adults, were not asked again about a robot for security, as the scenario question were only used if those types of tasks had not previously been mentioned. Thus there were 34 participants' responses that were coded.

Tasks. When asked what a robot used for security would do in their home, participants typically gave four types of answers: emergency notification, general home monitoring, passive security monitoring, and active security. The most common of these four types of answers was passive security monitoring, defined as any task in which the robot would monitor for intruders or unusual activity in the home (e.g., “I assume it would be like an alarm system of some sort on your doors, your windows, that type thing.”). Passive security monitoring was mentioned by 89% of participants. Fewer participants, 28%, stated that the robot would actively defend the home against intruders (e.g., “It would be like a bodyguard, so that if someone did enter, it could fight them off”). Eight out of the ten participants who stated that the robot would actively defend the home were younger adults.

Emergency notification tasks were mentioned by 52% of participants. These tasks were defined as any tasks in which the robot would notify an outside source of an emergency in the home, for instance the police or fire department. For example an 81-year-old participant, when asked what a robot used for security would do in his home, replied:

> At our age, the prospects of us having a heart attack or having a stroke are very good. We have a panic button that’s located two places in our unit. It’s really a chain. If we need emergency care we pull that chain and we’ve got a group of people, a team, that comes quickly…..I would want that robot to be my panic button.

For this participant, a robot for security would be used to enhance his own personal security in the case of a medical emergency. The robot would replace an existing emergency system.

The final type of tasks that participants mentioned for a security robot were tasks involved in monitoring the home for things other than intruders, such as gas leaks or smoke (e.g., “If a fire started…let you know to get out.”). Fewer participants, 17%, mentioned these types of task compared to the three other types of tasks.

Appearance. Participants’ statements about the appearance of a robot for security in their home were coded for comparisons to previously described robots as well as overall robot appearance. About 31% of participants referred to previously described robots when describing the appearance of a robot for security; eight participants stated the robot had the same appearance and three said it had a different appearance. A similar number of participants stated that a robot for security would look human-like as machine-like, 22% and 25% of participants respectively. There were four participants that described the robot as looking like an existing device (e.g., Very much like the security systems that we now have; keypads, perhaps a screen.”).

Control. When asked about how a robot used for security would know what to do, most participants, 78%, mentioned some type of programming. Again, participants’ statements were largely about general programming, although seven participants did specify that the robot would come pre-programmed. Only two participants stated that they would program the robot themselves. Direct control was mentioned infrequently, with only four participants stating this would be the way that a robot for security would know what to do (e.g., “Press a key number to start it and a key number to stop it.”).

A quarter of participants made statements that a robot for security would have sensors (e.g., "[The robot] would have some range that he could tell temperature if it's too high or sense danger."; "It could detect motion.").

Overall Opinion. When asked about their overall opinion about a robot for security in their home, 69% of participants made comments about their overall attitudes towards such a robot. The large majority of these comments reflected positive attitudes towards a security robot (e.g., "I think they'd be good"; "I would find it very worthwhile."). Half of participants also mentioned that such a robot would provide benefits (e.g., "It'd add an extra secure feeling to the homeowner and his family."). There were four participants who made statements about the feasibility of a security robot, with two participants stating that such a robot was feasible (e.g., "We have them now.") and two participants stating that they did not think or did not know if such robots were feasible (e.g., "I don't see how it could be done to tell you the truth.").

Negative Qualities and Characteristics of a Robot for the Home

Throughout much of the interview participants were asked to imagine a robot that they would want in their home, generally letting them imagine an "ideal" robot. Near the end of the interview, participants were asked to think about a robot that they would not want or not enjoy in their home and to describe the qualities or characteristics of this robot. Figure 20 shows the types of qualities and characteristics that participants would not want for a robot in their home. As seen in the figure, participants made the most statements about not wanting the robot in their home to be disruptive or intrusive (e.g.,

“…get in the way or be a tripping hazard.”; “annoyed me”), difficult to maintain (e.g., “breaks down”), or uncontrollable (e.g., “Have a robot that you couldn’t control. That once it was programmed to do something it did it regardless of what the outside situation was.”). There were three unwanted characteristics or qualities of robots that only younger adults mentioned: aggressiveness (e.g., “I wouldn’t want the robot to be very aggressive…be shouting or screaming…”)., human-like appearance (e.g., “If it looked at all human.”), and reasoning ability (e.g., “I wouldn’t want the robot to question my logic.”).

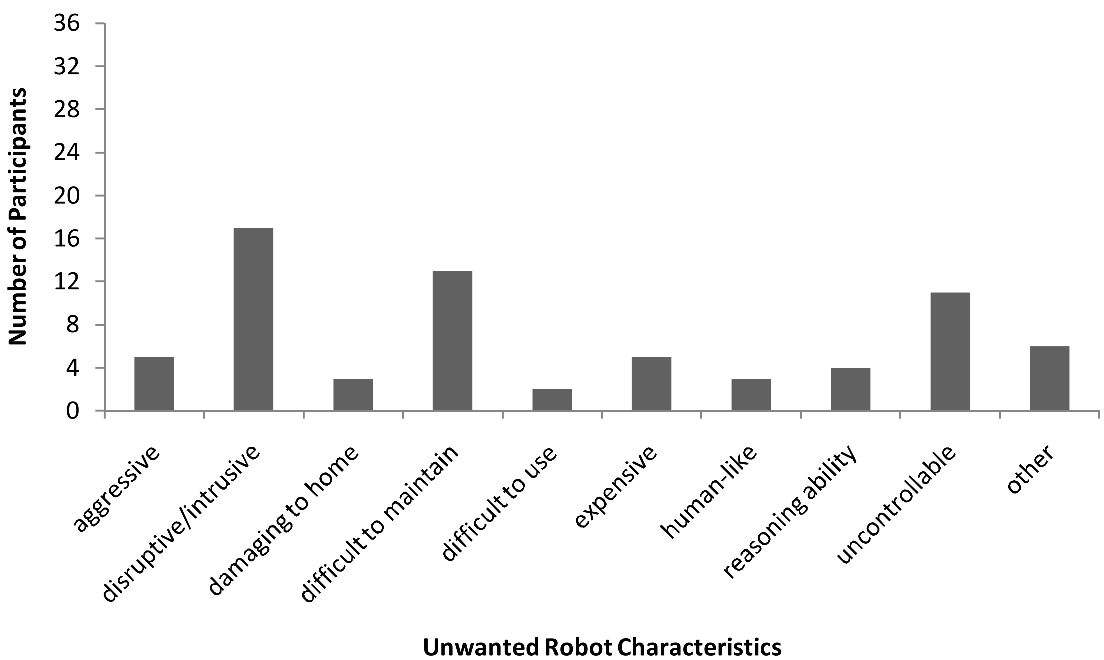

Figure 20. A graph showing the number of participants who stated each characteristic or quality of a robot that they would not want in their home.

Considerations before getting a Robot for the Home

Participants were asked what they would want to know about a robot before getting it for their home. The graph in Figure 21 shows the types to information that participants wanted to know about the robot and the number of participants who mentioned each type. The most commonly mentioned type of information was the capability of the robot, or its usefulness (e.g., "I would like to know everything that it's capable of doing"). Other frequently mentioned information that participants wanted to know about a robot before getting it was how easy it would be to use the robot or how the robot would be controlled (e.g., "I would like to know how easy it is to use"; "How can I program it?"), maintenance information (e.g., "I would like to know what my responsibilities would be to maintain the robot"), and its cost.

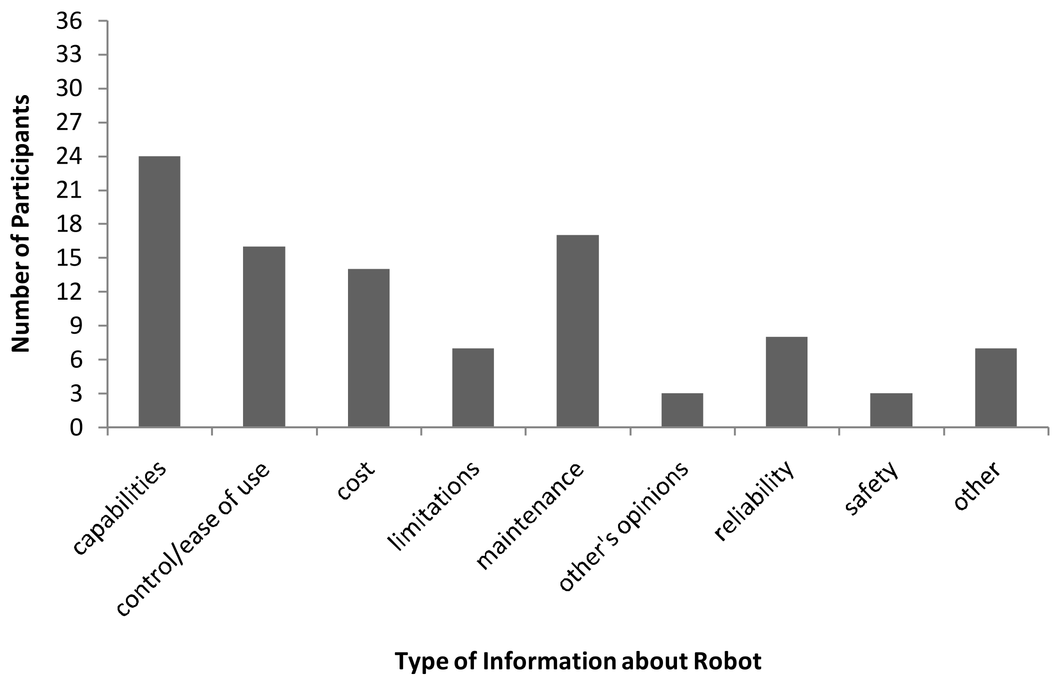

Figure 21. Types of information participants reported wanting to know about a robot before getting one.

Changes in Lifestyle with the Addition of a Robot in the Home

Participants were asked whether they thought they would need to adjust their lifestyle with the addition of a robot in their home. Many participants, 42%, responded that they did not think that lifestyle changes would be necessary (e.g., “It doesn’t seem like it, no”). There were four of these participants who explicitly stated that they would not get a robot if it meant having to change their lifestyle (e.g., “I would not adjust my lifestyle for a robot”).

Of the participants who responded that they would need to adjust their lifestyle for a robot, there were positive, neutral, and negative lifestyle changes that were mentioned. Almost a third of participants, 31%, mentioned that a robot in their home would result in a positive lifestyle change. This change was typically described as an increase in time to do other activities or an increase in the quality of life (e.g., "…more time to do other things as opposed to the things that the robot is going to do for me"). Neutral lifestyle changes were also mentioned frequently, with 44% of participants responding that a robot in their home would result in some lifestyle changes, but not specifically in a positive or negative way (e.g., "I would adjust my lifestyle: I wouldn't have as much activity to do so that is an adjustment"). Finally, five participants mentioned negative lifestyle changes that they thought would occur with the addition of a robot in their home. These negative changes included changes in tasks to accommodate the robot in the home (e.g., "…move things out of the way where [the robot] could get to them"), as well as negative changes to one's character. For instance one younger adult responded:

> My lifestyle is going to change. I think it's going to make me more lazy, definitely. It's going to make me more dependent on someone, which I know it's not good, but I guess it's just due to the lazy nature of the human being to do this. I do expect a change in my lifestyle. If I'm not going to be working that hard or if I'm not going to be doing all the physical chores or paying my bills and getting the groceries and stuff, I guess it is going to change me. I'm afraid it might make me lazy and might get me into smoking or drinking more. It might just make me fat. It's going to change something, definitely.

So whereas many participants' comments about lifestyle changes were positive, there were also comments made that suggested that participants did not know whether their lifestyle changes would be for the better or worse and a few comments that suggested that the robot would result in some negative changes to lifestyle.

Changes in Views or Opinions about Robots in the Home

The last question that participants were asked in the interview was whether they felt their opinions or views about robots had changed from the beginning of the interview to the end of the interview. Slightly over half of participants 58%, responded that their opinions or views had indeed changed.

A third of participants mentioned that they had never thought about robots in their home (e.g., "I never thought about robots before we started talking about [them]") or had changed their perceptions about the feasibility or attitudes towards robots in their home (e.g., "I think I'm more aware that robots are in our time and that these things…are more realistic"). For these participants, the interview had made them think about a topic they had not previously given much thought to- robots in the home- and had, overall, made them more aware that robots could enter the domestic environment.

Another common type of change reported by participants was a change in the perception of the types or quantity of tasks that robots could perform in the home, with 28% of participants mentioning this type of change. Many participants responded that they had never thought of a robot as doing more than housework. For example a 26-year-old female, when asked if her opinion or view of robots had changed replied:

> Yeah. I think I only thought of them for whatever reason as capable of just doing menial chores around the house,

> but I really like the one for having one for security and one for somebody that needed constant health care.

For this participant and several others, it appeared that the scenario questions with robots performing tasks other than cleaning had influenced or changed their perceptions about the types of tasks that robots could do in the home.

Exit Questionnaire

After completing the interview, participants were asked to answer some additional questions on an exit questionnaire.

The first question on the exit questionnaire was whether participants had previously thought about a robot in their home. Fourteen participants indicated that they had and 22 participants that they had never thought about what it would be like to have a robot in their home before the interview. A chi-square analysis, indicated no significant age group difference in whether participants had or had not previously thought about a robot in their home, χ^2 (2, N = 36) = 3.04, p = .22.

The next thing that participants were asked to indicate on the exit questionnaire was how easy or difficult it was for them to imagine a robot in their home, on a scale from 1 = "difficult to imagine" to 5 = "easy to imagine". Younger adults (M = 3.5, SD = 1.09), younger-older (M = 3.75, SD = 1.29), and older-older (M = 3.58, SD = 1.24) all had mean scores that indicated moderate ease in imaging a robot in the home. An

ANOVA with response as the dependent variable and age group as the independent variable indicated no difference in scores due to age group, $F(2, 33) = .133$, $p = .88$.

Lastly, participants were asked what they did to imagine a robot in their home. Twelve participants indicated they had thought of an existing device or machine. Devices listed included a vacuum cleaner, Roomba, TV, motion sensor, coffee maker, and computer. Twenty-six participants indicated that they had thought of a fictional robot. These fictional robots included R2D2, I-Robot, Rosie from The Jetsons, and the Lost in Space robot. Nine participants indicated they had thought about a non-fictional robot. They cited articles in Scientific America, MIT's walking robot, and auto production robots. Twenty-nine participants thought about the tasks a robot would do in their home and twenty pictured their home first and imagined a robot in it. Two participants indicated that they were not able to imagine a robot in their home.

Summary of Interview Results and Discussion

The purpose of the interview study was to gain an in-depth understanding of individuals' expectations of and attitudes towards a robot in their home. There were six main goals, to identify: 1) how individuals define "robot", 2) the types of tasks that individuals expect a robot to have in their home and the unifying properties of those tasks, 3) what individuals expect a robot in their home to look like, 4) attitudes toward a robot in the home, 5) expectations of and attitudes towards robots with non-cleaning tasks, and 6) how individuals would make the decision to accept a robot in their home.

How do Individuals Define Robots?

The participants in this study tended to think of robots as machine or devices that perform tasks that a human would typically do. Some participants thought that the definition should include some human-likeness in terms of appearance, but this was not a view expressed by a majority of participants. The way a robot is controlled or knows what to do was also not mentioned frequently. Participants who did mention control typically had a general idea that a robot would be programmed. The reason that participants define robots in this way appears to be mostly from exposure to robots in media, such as TV, movies, and books. Also, experience with robots such as the Roomba or factory robots, and thinking about the functionality of robots appears to influence how some people define the characteristics of a robot.

The definition of robot that most participants gave would not be sufficient in distinguishing it from other types of technology such as personal computers. However when asked specifically what makes a robot different from other types of technology, most participants indicated a belief that there is indeed something unique about robots. Most commonly, participants thought that the qualities and quantities of tasks that robots perform distinguishes them from other types of technology. They thought of robots as performing tasks that a human would do, more types of tasks, or more complex tasks. Participants also tended to think of robots as more programmed or automatic, more mobile, and more intelligent than other types of technology. In summary, it seems that individuals think of "robotness" less in terms of appearance and more in terms of functionality.

What are the Tasks that Individuals Expect a Robot to Perform in their Home and How would a Robot Know how to do Those Tasks?

It comes as no surprise that almost all participants imagined a robot in their home performing cleaning and organizing activities, such a vacuuming and washing the dishes. (Khan, 1998). In general, participants wanted a robot in their home to carry out tasks they perceived as time consuming or boring. They saw a robot as a time-saving device that would give them more time to do the things that they wanted to do. Several older adults, however, also saw a robot as being an assistive device by helping them to carry out tasks that are difficult now or may be difficult in the future. For these individuals, a robot could be a way to live independently in their own homes for a longer period of time.

Typically, participants imagined a robot in their home performing tasks daily or when needed. They tended to think about how often tasks should get done, and then scheduled the robot around these ideal frequencies.

Because participants mostly saw robots as time saving devices performing mundane activities, they did not see themselves interacting with the robot. Even when participants imagined themselves with the robot they tended to see their role as monitor or manager rather than teammate or collaborator. Participants typically imagined being in the home when the robot was active, but doing their own tasks. Some evidence also emerged to suggest that younger adults would be more willing than older adults to let robots perform tasks on their own and would rather not be bothered with the robot. Older adults had a tendency to want to be in the same location as the robot to watch its performance. As a general trend, they indicated more caution in leaving a robot to perform tasks on its own. Still, there were some older adults who had no hesitation about leaving a robot alone in the house when they went out to do other activities.

Although participants had many ideas about what a robot could do in their home, they seemed to have more difficulty in imagining how it would know how to do those things. It may be that they realized that today's technology may not be able to handle all the tasks that an "ideal" robot would perform in the home. Another explanation may be that individuals are more concerned with *what* robots can do for them and less with *how* robots would actually do those things.

The idea that a robot would be programmed was generally as in depth as people got in thinking about how a robot would know how to carry out tasks. Although participants were not probed about what "programmed" actually meant to them, programming implies something about how individuals may expect to interact with robots. For instance individuals may not expect to have a lot of direct interaction with a robot and a programmed robot could be easy to use because it has some existing knowledge to help it carry out tasks. Younger adults were more explicit than older adults in saying that they would program the robot. This is likely due to younger adults having more experience than older adults with technology and computers.

When participants did give more detailed information about how a robot would know what to do, many mentioned voice commands. This was consistent with findings from the previous studies (e.g., Scopelliti, Giuliani, & Fornara, 2005). Voice commands provide a way to control robots that is easy and intuitive from the standpoint of the human user. From a programming standpoint, voice commands may be more difficult to implement than other forms of control due to the need to interpret people's use of abstract language (Drygajlo, Prodanov, Ramel, Meisser, & Siegwart, 2003). Few participants mentioned sensors in stating how robots would know how to carry out the tasks that the user would want them to do. Overall this suggests that participants thought about what would be the easiest ways for them to instruct a robot to perform tasks and not necessarily about the complexity of the task for a robot.

Most participants indicated discomfort with having robots make decisions about what tasks to do on their own. Exceptions to this were participants who thought that the robot's knowledge could compensate for their own lack of knowledge about technology. For example they thought that if they entered a wrong command, the robot would be able to interpret what was supposed to be entered. Some participants also did not have a problem with a robot performing tasks it had previously been instructed to carry out or tasks that came out of unexpected situations.

An indication about how participants felt about a robot in their home was what they imagined the robot would do when it was done with its tasks. Most participants indicated that a robot would be turned off and stored out of view or out of the way when not in use. This again suggests that participants thought of a robot in their home as a complex appliance, there to carry out specific functions; there would be no reason for it to be seen or in the way when it was not actively performing tasks.

To sum up participants' beliefs about a robot performing tasks in their home: Participants generally imagined a robot as a complex appliance performing tasks that they themselves did not want to do or needed help doing. They wanted a robot to perform tasks regularly but did not imagine themselves interacting much with the robot.

Participants had clear ideas about what tasks a robot should do and but did not necessarily discern how the robot would know how to do those tasks.

What do individuals expect a robot in the home to look like?

Participants expressed many variations in what they expected a robot in their home to look like. There were about an equal number of participants who imagined a robot with a very human-like appearance as those that imagined one with a very machine-like appearance. Older-older adults, however, were the least likely of the three age groups to imagine a robot that was very human-like. In general, older adults more likely to imagine robots as looking like existing devices already in the home. One commonality in answers was what a robot would be made of, with most participants stating metal and/or plastic. Few participants stated that their robot had a gender, although quite a few participants would refer to the robot as "he".

There were some similarities and some differences in the ways that participants described the appearance of a robot in the interview study compared to how participants in the questionnaire study did. Two similarities were that participants tended to imagine a robot shorter than a human and were not likely to describe interaction features such as buttons or screens. One important difference between the way interview and questionnaire participants described their robot was that few participants in the interview mentioned a robot with a head or facial features. It may be that a drawn robot may seem unusual without a head, whereas when a robot is verbally described, the lack of head or facial features may not be as disconcerting. Additionally, arms were not mentioned as frequently as in questionnaire and wheels were mentioned more often than legs for mobility.

Why did participants think this was the way that robots would look? Most participants rationalized that a robot needed to look the way they had described because of functionality. They perhaps imagined that a robot in the home would need to maneuver in small spaces and not knock things over, but still have the tools needed to perform tasks. Participants who described less human-like and more machine-like robots were the mostly likely to say functionality as the reason the robot would look the way they had described. Other participants mentioned reasons such as previous experiences with robots and influence from media sources.

What are Individuals' Attitudes toward a Robot for their Home?

Participants were not asked directly about their attitudes toward a robot in their home because it would be unlikely that they would be able to verbalize how they felt about such a robot. Instead, attitudes were investigated through indirect questions about the robot's access to different parts of the home, other users of the robot, the robot's activities when guests were present and when the participant was away from the home, and what the participant would do if the robot malfunctioned.

When asked which places the robot would and would not have access to in the home, many participants thought the robot could go anywhere in the house, whereas others did not see why it should go to places where it did not need to be. Some participants expressed concerns that the robot would hurt certain people or damage items in the home. Also, despite the robot being a machine, some participants did not feel comfortable having the robot in places where they wanted privacy, such as the bedroom or bathroom. Thus there seemed to be two distinct attitudes towards a robot in the home: either participants did not feel a robot as being an intrusive technology or they had concerns that a robot would interfere with the existing structure of the home environment.

For the most part, participants did not imagine robots as being personalized for different individuals in the home. They indicated that other people besides themselves would use the robot, but these other people would use the robot in the same way that they would. Basically, a robot in the home would be a shared device that functioned in a singular way no matter who was telling it what to do.

Another telling sign of how participants felt about a robot in their home was what the robot would do when guests were over. If a robot was seen as a part of the family it might interact with guests whereas an appliance would probably be off and in storage or used only before guests came or after they left. Mostly participants imagined the robot off or in storage when guests were over. This suggested that they thought of a robot as an appliance and there was no need for guests to see it. Maybe they thought that having a robot would be embarrassing, or they did not want to have to deal with a robot when they needed to focus on accommodating guests. Several participants mentioned new types of tasks for the robot to do when guests were over, but these were mostly tasks that would make hosting guests easier, such as additional cleaning tasks. Younger adults were interested in having the robot serve guests, but even they saw a robot as being in the background of activities rather than in the forefront.

Another type of attitude that was assessed was the comfort level that participants felt with leaving the robot alone in the home for a shorter period of time and a longer period of time. Most participants thought the robot should be off when they were away from home. Younger adults were more likely than older adults to want the robot off, if it was done with its assigned tasks, rather than off in general. It may be inferred that many participants felt uncomfortable with having the robot be active when they were away from home, or they simply did not see a need for it to be on when they were away. Participants were unlikely to mention any new types of tasks the robot could do when they were away for a few hours, but some participants thought that the robot could protect the house when they were away for a week. Not only did these participant feel comfortable having a robot active when they were away for an extended period of time, but they also saw new possibilities for the robot besides cleaning tasks.

Finally, participants' attitudes about a robot in their home were assessed by asking them what they would do if the robot made a mistake or if the robot broke down. Most participants imagined that they would try to fix the robot themselves if it made a mistake but would not want to deal with it if it broke down. Several participants thought that they would be able to teach the robot about a mistake it had made and how to not make that mistake again; they imagined the robot intelligent enough to understand. In the case of the robot breaking down most participants indicated that they would get an expert to fix it. In general they saw a robot as too technologically advanced for them to try to fix it themselves. Several participants said they would get a new robot if the old one broke, suggesting little attachment to their robot.

So overall in term of attitudes toward a robot in the home, participants showed more inclination to thinking about a robot as an appliance than as a part of the family. They did not tend to view a robot as a personalized device. Whereas some participants were comfortable with a having a robot roam the house and do tasks even when they were away, many participants felt some discomfort in having a robot be too autonomous. They indicated a willingness to invest time to fix a robot that made a mistake, but viewed a robot breaking down as a task to difficult for them to deal with on their own.

What are Individuals' Expectations and Attitudes about Robots for Entertainment-, Health-, and Security-Related Tasks?

As expected, participants initially imagined a robot in their home that would perform repetitive tasks such as cleaning. The investigation of what a robot in the home should do could have stopped there. However, there are many other types of tasks that robots could do in the home. It was important to see the attitudes that participants would have towards robots performing these alternative types of tasks. Basically, do most people say "cleaning" when asked what a robot in their home would do because that is all they are interested in having a robot do, or are they simply not aware of the broad range of tasks that a robot in the home could potentially perform?

Participants were presented with three robot tasks scenarios: a robot for entertainment, for health-related activities, and for security. These were purposefully left ambiguous, so that participants would have to decide what "entertainment", "health-related activities", and "security" meant to them.

For entertainment, many participants pictured a robot providing direct entertainment. Most of the time, this direct entertainment was one-sided meaning that the robot would be active, for example singing, and the person would be passive, in this case listening. Many participants also imagined the robot replacing existing devices, such as a CD player, or interacting with existing devices, such as changing the channels on a TV set. Thus participants tended to think about current ways that they are entertained (e.g., listening to music or watching TV) and tried to fit a robot into those existing activities. Few participants imagined interactive types of activities in which the robot could replace a human.

For health-related activities, participants described a range of tasks that robots could do, from promotion of health activities to medication administration. For these types of tasks, they tended to see a robot as aiding them with health, much like a care person or a coach would, rather than replacing existing devices. Participants saw health needs for themselves or others that were not currently being fulfilled, but could be through a robot.

For security tasks, participants thought that robots could provide emergency notification, home monitoring for unexpected events and intruders, and, for younger adults, active defense of the home. There was a tendency for participants to think of a robot for security as replacing existing home security systems, but with more functionality (e.g., turning lights on and off to make it seem like someone was at home).

The types of tasks that participants mentioned for entertainment, health-related activities, and security suggest the ways that individuals may think about what a robot could be used for: If tasks are already being performed by other devices, then a robot would perform similar tasks. If there is a need that is not being met, and current devices either are insufficient or do not exist, then a robot could do tasks that fulfill that need.

In terms of the appearance of robots for the entertainment-, health-, and security-related tasks, many participants indicated that the look of the robot would remain similar no matter what the robot was doing. It seems that the appearance of a robot is not necessarily tied to functionality. An alternative explanation is that once participants imagined a robot for their home it was difficult for them to imagine a robot with a totally different look.

In respect to how participants imagined a robot in their home would know what to do for the three robot task domains, programming again was mentioned most frequently. There were differences, however, in the number of participants who indicated direct control methods for entertainment, health-related, and security robots. Direct control of a robot for entertainment was mentioned much more frequently then it was for health-related activities; it was least mentioned for a security robot. One explanation is that since existing entertainment devices typically function through direct control, participants assumed that the robot would be controlled this way as well. They may have also thought of an entertainment robot as entertaining on command instead of being scheduled to entertain. For security activities, participants mostly describe robots performing monitoring tasks over an extended period of time. They may have not seen a need to interact with a robot, as it would only really be needed for rare events. Additionally, sensors were mentioned much more frequently for security tasks than for any other types of tasks. With monitoring activities participants may have realized that a robot would need sensing capabilities, something that was not so obvious when they were thinking about a robot for cleaning or other mundane, repetitive tasks.

Participants' opinions and attitudes about robots for entertainment-, heath-, and security-related tasks varied. Generally, if participants imagined tasks that would benefit them or others in some way, they had overall positive attitudes about a robot performing those tasks. This is likely why there were fewer positive comments about a robot for entertainment compared to a robot for health-related activities and security. Some participants, however, were fearful about robots performing more critical tasks, such as medication administration. So whereas participants saw more benefits in having robots perform critical tasks versus novelty-type tasks, they had concerns about how much trust to place in these types of robots.

To summarize participants' perceptions about robots for entertainment, health, and security: When presented with these three task domains, participants generally had little trouble describing what kinds of tasks these robots would do. Their attitudes toward robots for these task domains were closely tied to whether they saw benefits of having robots perform these tasks. This all suggests that participants' initial expectations about what a robot could do in their home were limited mostly because they are unaware of other types of tasks that robots could possibly do.

What May Influence Individuals to Accept a Robot for their Home?

One primary goal of this study was to identify what characteristics of a robot would make individuals more or less likely to accept it in their home. An important finding was that participants did appear willing to have a robot in their home if they saw the robots as being useful. Participants indicated wanting to be knowledgeable about a robot before putting one in their home. They wanted to know the capabilities of a robot and also how easy it would be to use, control, and maintain. Participants did express some concerns about a robot in the home. In particular, they did not want a robot that was intrusive, disruptive, or noisy. Their responses gave support to the TAM-related variables of usefulness and ease of use in predicting acceptance of a robot for the home. Basically, participants wanted to know that the benefits a robot could provide would outweigh the effort it would take to have and maintain a robot within the home.

For the most part, participants did not imagine that they would need to adjust their lifestyle for a robot. If they did mention changes, they were often for the better, for example having more time to do one's own activities. This suggests that individuals want a robot that conforms to the existing social structure of the home. They might be less accepting of a robot that would require them to make changes to their existing lifestyle.

Finally, quite a few participants mentioned that their opinions or views of robots had changed during the interview. In particular, participants mentioned that they now thought that robots were more feasible than previously. Several participants said that their beliefs in the types or quantity of tasks that a robot could perform in their home had changed; they had gone from a narrower view to a broader view of what a robot could do. In summary, participants generally became more accepting of robots as a result of thinking in depth about them, particularly in terms of the variety of activities that robots might perform in the home.

CHAPTER 6: GENERAL DISCUSSION AND CONCLUSION

The findings from the questionnaire and interview studies provide an important contribution to human-robot interaction research because they help us understand current expectations and attitudes individuals have about a robot in their home. By understanding current expectations and attitudes we can start to predict under what conditions people will and will not be accepting of such robots. Furthermore, the studies are likely the most comprehensive to date in examining older adults' perceptions of home-based robots.

The main objective of the studies was to address whether individuals would be accepting of a robot in their home. Overall the results suggest that, yes: individuals are willing to have a robot in their home. Participants demonstrated generally positive attitudes towards such robots. The results, however, also suggest that people would not be equally accepting of all robots; a robot for the home would need to have clear benefits for the people living in the home. Individuals would be unlikely to accept a robot in which the costs of having a robot, in terms of things like interaction commitments, annoyance, or maintenance issues, would outweigh the benefits of having a robot.

Another contribution of the studies is that the results contradicted the belief that older adults would be less willing to have a robot in their home than younger adults. Previous research has suggested that older adults may be more fearful of robots (Scopelliti, Giuliani, & Fornara, 2005). In these studies there were some differences in younger and older adults' expectations of and attitudes toward a robot for their home, for example in terms of appearance, types of task, and need for monitoring. Despite these differences, older adults were more similar to younger adults in their perceptions of a robot in their home than different. Older adults were just as enthusiastic about having a robot in their home as were younger adults, if they saw the robot as benefit them and making their lives easier. The results support previous research that has demonstrated that older adults are open to technology in the home if it allows them to live independently (Caine, Fisk, & Rogers, 2007; Melenhorst, Rogers, & Bouwhuis, 2006; Sharit, Czaja, Perdomo, & Lee, 2004). Overall, it appears that technology experience mitigates age-related differences in expectations of and attitudes towards robots for the home. If there is any one point that should come out of this research, is that older adults are willing to have a robot in their home. They should not be excluded when it comes to the implementation of home-based robots.

An initial assumption of this research was that there would be prototypical robot characteristics that would be shared by most individuals. The results of the studies show that there are many ways that people imagine robots. Some individuals imagine very human-like robots whereas others imagine very machine-like robots. Most people tend to envision robots that have characteristics of both humans and machines. One commonality in expected robot characteristics is that robots should be designed to be productive. A robot for the home should assist a person in the way they need to be assisted. Designers and researchers of robots have focused much attention on designing robots that are believable and demonstrate social intelligence (Dautenhahn, 2004). Although this study does not suggest that these areas are unimportant, it does suggest that a believable, socially intelligent robot may not be fully accepted by an individual if he or she does not see the robot as being useful.

Another implication of the studies is that it not sufficient to assume that since most people say cleaning or other routine household task, when asked what they would want a robot to do in their home, that this is the only thing they would accept a robot for. Participants in both studies started out with very narrow views of robots and what they could do in their home. These narrow views likely emerged from exposure to robots in media and experience with existing consumer robots (e.g., Roomba). When participants were exposed to other types of tasks that a robot could possibly do, they generally indicated willingness to have a robot do those tasks. Again, this was only if they saw how a robot doing those tasks would be useful and would not require too much effort on their part to use.

Finally, the studies show the importance of using two complementary strategies in conducting exploratory research. The questionnaire study allowed for the statistical relationships between age, technology experience, robot experience, expectations, and attitudes toward a robot in the home to be investigated. It provided extensive information about how younger and older adults think about robots as well as provided evidence for the robustness of the Technology Acceptance Model. The interview study, not only supported the findings from the questionnaire, but also helped to uncover why individuals imagine a robot in their home the way that they do, their concerns about such a robot, and their expectations about what a robot would do in typical and non-typical situations. The complementary approaches allowed for a rich understanding of younger and older adults' expectations of and attitudes toward a robot in their home, the data from only one of the approaches would not have been as compelling.

Limitations of study

Clearly the two studies had many limitations. Most obviously were the low return rate in the questionnaire study and the small sample size in the interview study. The sample of participants may not have been representative of the larger population. For example it is likely that individuals with more positive views about robots, or more interest in them, were more likely to fill out and return the questionnaire than individuals with negative or ambivalent views about robots. The comprehensive nature of the interviews limited the number of participants that could be included. Although patterns between age groups could be identified, the small number of participants in each group prevented full statistical analysis of age-related differences in expectations of and attitudes toward a robot in the home.

Other limitations to the study were due to the instruments used. Much of the questionnaire study relied on exploratory factor analysis techniques, which are influenced by the selection of variables and the open interpretation of the researcher. In the interview study, many questions required participants to rationalize their answers. Participants may have given answers that appeared logical but were not accurate. This is not to imply that participants were lying, but rather that they were not fully aware of why they had certain beliefs about robots.

Another concern was that many participants indicated that their perceptions of a robot had changed through the course of completing the questionnaire or answering questions in the interview. This finding can be considered problematic because the measurement instruments had changed what was being measured.

Despite the limitations of the studies, overall they were successful in providing large amounts of information about current perceptions of robots in the home. Exploratory approaches, such as the ones used in the present studies, are important in building a research base to inform future confirmatory research in the domain.

Future Directions

The results of the studies suggest that, in general, individuals have high attitudinal acceptance of a robot in their home. Attitudinal acceptance, although predictive of behavioral acceptance, does not fully predict whether an individual will or will not purchase and use new technology. Future research in robots for the home should ideally examine expectations of and attitudes towards a robot in the home for a broader range of individuals in the context of predicting behavioral acceptance. For example, the questionnaire can be given to participants before a robot is placed in their home. The predictive ability of the questionnaire could then be assessed by looking at participants' use of the robot over a period of time. It will also be important to examine how participant's attitudes about robots may change after interacting with real robots over this time period. Additionally, it will be critical for future studies to look at whether general perceptions about all robots can predict behavior with a specific robot. It is likely that robot appearance and social intelligence will influence behavioral acceptance of robots more than would be suggested by the results of these studies.

Conclusion

As technology advances, it is likely that robots in the home will become common place. With an aging population, it is foreseeable that many of these home-based robots will be designed specifically for older adults. Potentially, robots could assist older adults in performing tasks that would allow them to live independently in their own home over a longer period of time.

Although there have been huge advances in what robots can do, these advances have largely occurred in isolation of individuals' current perceptions of home-based robots. Robots designed without the consideration of user's expectations may not be able to fulfill their needs. The objective of the studies was thus to understand individuals' perceptions of robots so as to inform the direction of robot development. The studies addressed the issues of expectations of and attitudes toward home-based robots by younger and older individuals and provided a research base on which acceptance of such robots could be predicted.

The results of the studies indicate that younger and older individuals are, for the most part, open to the idea of a robot in their home if they expect the robot to be useful and not too difficult to use. It is suggested that robot designers address the needs of individuals in the home, particularly the needs of older adults if they plan to develop robots for this age group. Furthermore, they should be attentive to the concerns, such as intrusiveness, that individuals have about a robot in their home. In general, older adults are excited about the prospect of a robot in their home. It is now the job of robot designers to make sure that robots for older adults are catered to what individuals in this age group want and need.

APPENDIX A: COVER LETTER

Dear Sir/Madam,

We are contacting you about a research project that you might be interested in. Here at the Georgia Institute of Technology, we are interested in what people expect robots in their home to be like. We are also interested in differences between younger and older adults' views about robots in their home. The results of this study may have impact on how robots for the home are designed. In this specific questionnaire, we are contacting people living in the Atlanta area to understand their expectations of and attitudes towards robots in their home.

We retrieved your name and contact information from a database of Atlanta area residents between the ages of 18-28 and 65-85. The survey was developed by researchers at Georgia Institute of Technology, and is being distributed by the Survey Research Center at The University of Georgia. All information from this questionnaire will be kept anonymous. All identifying information will be separated from your answers. To ensure that your questionnaire is anonymous, please do not put your name anywhere on the questionnaire or the return envelope. There will be no way to match the completed questionnaires to a particular person. You will not be put on a mailing list. Only the researchers involved in this study will see the completed questionnaires.

We expect this questionnaire to take 45-90 minutes to complete. The questionnaire should be completed by the person to whom the envelope was addressed to. We ask that you try to answer the survey in one sitting, or that you take breaks at the end of a section, rather than in the middle of a section.

Whether you decide to complete the questionnaire or not, you have the chance to be entered in a sweepstakes. We will be giving fifty $50 gift certificates. At least 1 out of every 100 people who enter will win. Just complete and return the colored form to enter the sweepstakes. Also, regardless of whether the questionnaire is completed, we will provide you with a summary of the findings if you are interested. Please indicate on the sweepstakes entry form if you are interested in received a summary of the results of the research.

Please return the questionnaire by **April 1st, 2008** in the pre-paid and pre-labeled envelope. If you have any questions or concerns, please contact Dr. Arthur D. Fisk (404-894-6066) or Dr. Wendy Rogers (404-894-6775).

We thank you for your help.

Sincerely,

Arthur D. Fisk & Wendy A. Rogers

APPENDIX B: INITIAL QUESTIONS

This is the blue sheet

<u>*ANSWER THESE QUESTIONS FIRST***</u>**

<u>INSTRUCTIONS:</u> There are many types of robots being developed for use in the home. In this section we would like you to think about what a robot in your home might be like.

Imagine someone gives you a robot for your home. Please take a few minutes and try to form a picture in your mind about what the robot looks like, acts like, and does in your home.

1. In the space below, please <u>describe</u> the robot as you imagine it in your home.

2. In the space below, please <u>draw</u> the robot as you imagine it in your home. (We will not be judging you on your drawing skills–just do the best you can).

Thank you for answering these questions. You may now continue by answering the questions on the survey. Please keep this blue sheet in front of you where you can see it. You will be asked to refer to this blue sheet when answering other questions on the survey. Please include this blue sheet when mailing in your questionnaire.

APPENDIX C: ROBOT QUESTIONNAIRE

Robot Questionnaire

February 2008

Questionnaire Conducted by:
Georgia Institute of Technology

Research Supported by the National Institutes of Health Grant Number P01 AG17211

Questionnaire distributed by: The Survey Research Center
University of Georgia

*****IF YOU HAVE NOT ANSWERED THE QUESTIONS ON THE BLUE SHEET** (THE ONE THAT SAYS "ANSWER THESE QUESTIONS FIRST"), **PLEASE DO SO NOW*****

- Please keep the blue sheet in front of you where you can see it.
  You will be asked to refer to the sheet when answering other questions.

- Please answer the questions on the following pages. All of your answers will be treated anonymously. Any published document regarding this survey will not identify individuals with their answers. If there is a question you do not wish to answer, please just leave it blank and go on to the next question. Thank you in advance for your help.

Section I. Views about Robots

Instructions: On the blue sheet you were asked to imagine a robot in your home. Please refer to the blue sheet to remember what you imagined a robot in your home to be like.

In this section you will be presented with different words. Please indicate how much those words match with the robot you imagined in your home. Remember, we are interested in your views, so there are no right or wrong answers.

Part A

1. How much does each of the following words match what you imagine a robot in your home might be like? Check one box for each description.

	Not at all$_1$	**To a limited extent**$_2$	**To a moderate extent**$_3$	**To a large extent**$_4$	**To a great extent**$_5$	**Don't know**$_0$
1. Agreeable						
2. Artificial						
3. Boring						
4. Breakable						
5. Calm						
6. Careless						

How much does each of the following words match what you imagine a robot in your home might be like? Check one box for each description.

	Not at all $_1$	**To a limited extent** $_2$	**To a moderate extent** $_3$	**To a large extent** $_4$	**To a great extent** $_5$	**Don't know** $_0$
7. Chaotic						
8. Clumsy						
9. Compassionate						
10. Complex						
11. Confident						
12. Coordinated						
13. Creative						
14. Demanding						

How much does each of the following words match what you imagine a robot in your home might be like? Check one box for each description.

	Not at all$_1$	**To a limited extent$_2$**	**To a moderate extent$_3$**	**To a large extent$_4$**	**To a great extent$_5$**	**Don't know$_0$**
15. Dependent						
16. Dull						
17. Dynamic						
18. Efficient						
19. Expressive						
20. Friendly						
21. Helpful						
22. Hostile						

How much does each of the following words match what you imagine a robot in your home might be like? Check one box for each description.

	Not at all$_1$	To a limited extent$_2$	To a moderate extent$_3$	To a large extent$_4$	To a great extent$_5$	Don't know$_0$
23. Independent						
24. Interesting						
25. Lazy						
26. Lifelike						
27. Motivated						
28. Nervous						
29. Playful						
30. Pointless						

How much does each of the following words match what you imagine a <u>robot in your home</u> might be like? Check <u>one</u> box for each description.

	Not at all$_1$	**To a limited extent$_2$**	**To a moderate extent$_3$**	**To a large extent$_4$**	**To a great extent$_5$**	**Don't know$_0$**
31. Precise						
32. Quiet						
33. Reliable						
34. Risky						
35. Safe						
36. Selfish						
37. Serious						
38. Simple						
39. Static						

How much does each of the following words match what you imagine a robot in your home might be like? Check one box for each description.

	Not at all$_1$	**To a limited extent**$_2$	**To a moderate extent**$_3$	**To a large extent**$_4$	**To a great extent**$_5$	**Don't know**$_0$
40. Sturdy						
41. Talkative						
42. Trustworthy						
43. Unfeeling						
44. Unimaginative						
45. Unpredictable						
46. Unsocial						
47. Useful						
48. Wasteful						

Part B

2. On the blue sheet you were asked to imagine a robot in your home. Please refer to the blue sheet to remember what you imagined a robot in your home to be like.

How much does each of the following descriptions match what you imagine a robot in your home might be like? Check one box for each description.

	Not at all$_1$	To a limited extent$_2$	To a moderate extent$_3$	To a large extent$_4$	To a great extent$_5$	Don't know$_0$
1. Like an Appliance						
2. Like an Assistant						
3. Like a Friend						
4. Like a Human						
5. Like a Machine						
6. Like a Pet						
7. Like a Servant						
8. Like a Teammate						
9. Like a Toy						

Part C

3. On the blue sheet you were asked to imagine a robot in your home. Please refer to the blue sheet to remember what you imagined a robot in your home to be like.

How much do you agree with the following statements as they relate to the image in your mind about a robot in your home? Check one box for each statement.

	Strongly Disagree 1	**Moderately Disagree** 2	**Neither Agree nor Disagree** 3	**Moderately Agree** 4	**Strongly Agree** 5	**Don't know** 0
1. Using the robot at home would increase my performance						
2. Using the robot at home would increase my productivity						
3. Using the robot at home would increase my effectiveness						
4. I would find the robot in my home useful						
5. Learning to use the robot in my home would be easy for me						
6. It would be easy for me to become skilled at interacting with the robot in my home						
7. I believe it would be easy to get the robot in my home to do what I want it to do						
8. Overall I believe the robot in my home would be easy to use						

Part D

On the blue sheet you were asked to imagine a robot in your home. Please refer to the blue sheet to remember what you imagined a robot in your home to be like.

4. Please indicate what your attitude is towards the robot in your home by circling one number (1-5) on each scale:

Bad	1	2	3	4	5	**Good**
Unfavorable	1	2	3	4	5	**Favorable**
Negative	1	2	3	4	5	**Positive**

5. Assume that the robot you imagined in your home were available for purchase, but you did not own one yet. Please indicate your intention to buy this robot for your home by circling one number (1-5) on each scale:

No intention	1	2	3	4	5	**Strong intention**
Unlikely	1	2	3	4	5	**Likely**
Not buy it	1	2	3	4	5	**Buy it**

6. Would you recommend the robot you imagined in your home to others (e.g., family or friends)? Please circle one number (1-5) on the following scale:

Not recommend	1	2	3	4	5	**Recommend**

6b. If you would recommend the robot to others, who would you recommend it to?

Section II. Robots Tasks

INSTRUCTIONS: In this section we would like you to think about tasks you would be willing to let robots perform in your home. You will be presented with different things that robots could do in your home. Please indicate how willing you would be to let a robot do each of these things by **placing a check in the appropriate box** for each question.

Part A

1. Now we would like you to think about different tasks that a robot in your home could do. How willing would you be to let a robot do the following tasks in your home? Check one box for each task.

	Not at all$_1$	**To a limited extent$_2$**	**To a moderate extent$_3$**	**To a large extent$_4$**	**To a great extent$_5$**	**Don't know/ doesn't apply to me$_0$**
1. Bring me things I need from another room in my home						
2. Teach me more about a hobby or topic of interest						
3. Give me information about the weather, news, etc.						
4. Have a conversation with me						
5. Help motivate me to exercise						

How willing would you be to let a robot do the following tasks in your home? Check one box for each task.

	Not at all$_1$	To a limited extent$_2$	To a moderate extent$_3$	To a large extent$_4$	To a great extent$_5$	Don't know/ doesn't apply to me$_0$
6. Help me stick to a diet (e.g., count calories, suggest food to eat)						
7. Help me with housework (e.g., vacuuming, washing dishes, cleaning)						
8. Inform my doctor if I have a medical emergency						
9. Make meals or cook for me						
10. Play games with me (e.g., tic-tac-toe, chess, video games)						
11. Remind me to take my medication						

How willing would you be to let a robot do the following tasks in your home? Check <u>one</u> box for each task.

	Not at all$_1$	**To a limited extent**$_2$	**To a moderate extent**$_3$	**To a large extent**$_4$	**To a great extent**$_5$	**Don't know/ doesn't apply to me**$_0$
12. Scare away an intruder						
13. Show me how to use other technology						
14. Teach me a new skill (e.g., learn a foreign language)						
15. Warn me about a danger in my home (e.g., fire, gas leak, carbon monoxide)						

Part B

2. On the blue sheet, we had asked you to describe and draw a picture of the robot you imagined in your home. Has the image of a robot in your home changed at all since you described it on the blue sheet?

☐1 Yes, the imagine in my mind of a robot in my home has changed

☐2 No, the image in my mind of a robot in my home has stayed exactly the same

2b. If YES, how has the image in your mind of a robot in your home changed?

Please describe below.

Section III. Technology/Robot Experience

INSTRUCTIONS: In this section we would like to know more about your experience with technology. Please answer the following questions by **placing a check in the appropriate box** for each question. All of your answers will be treated anonymously. If there is a question you do not wish to answer, please just leave it blank and go on to the next question.

Part A

1. Within the last year, how often have you used the following technologies? Check one box for each technology.

	Not at all$_1$	To a limited extent (once or twice in the year)$_2$	To a moderate extent (every couple of months)$_3$	To a large extent (several times a month)$_4$	To a great extent (several times a week)$_5$	Don't know what this is$_0$
1. Answering machine						
2. Automated teller machine (ATM)						
3. CD/DVD						
4. Cell phone						
5. Computer/video game (e.g., Gameboy, Playstation, X-Box)						
6. Credit card/Debit card						
7. Cruise control in a car						
8. Digital photography (e.g., digital camera, camcorder)						

Within the last year, how often have you used the following technologies? Check one box for each technology.

	Not at all$_1$	To a limited extent (once or twice in the year)$_2$	To a moderate extent (every couple of months)$_3$	To a large extent (several times a month)$_4$	To a great extent (several times a week)$_5$	Don't know what this is$_0$
9. Fitness device (e.g., pedometer, treadmill, pulse meter)						
10. Home medical device (e.g., blood-glucose meter)						
11. In-car navigation system (e.g., GPS, OnStar, Neverlost)						
12. In-store automatic kiosk (e.g., automatic checkout, price scanner)						
13. Internet/E-mail						
14. Microwave oven						
15. MP3/iPOD						
16. Non-digital camera						
17. Personal computer (PC)/ Laptop						
18. Personal digital assistant						
19. Telephone						
20. Washing machine						

Part B

2. The following is a list of different types of robots that are currently available. Please indicate how familiar you are with each type of robot. Check one box for each type of robot.

	No experience with this robot1	**Have heard or read about this robot**2	**Have seen this robot (e.g., on T.V., in a store)**3	**Have used this robot (e.g., at a friend's house)**4	**I have and use this robot**5	**I'm not sure**0
1. Robot factory machine (e.g., robotic arm in factory)						
2. Robot lawn mower						
3. Robot mopping device (e.g., Scooba)						
4. Robot security guard						
5. Robot toy (e.g., Sony Aibo, Furbie)						
6. Robot vacuum cleaner (e.g., Roomba)						
7. Other types of robot (please list)						

Part C

3. For each of the following activities listed in the table, please indicate how important technology is to the performance of that activity. Check one box for each activity.

	Not at all important $_1$	**Of limited importance** $_2$	**Of moderate importance** $_3$	**Of considerable importance** $_4$	**Of vital importance** $_5$	**Don't know** $_0$
1. Communication activities						
2. Financial activities						
3. Health care related activities for yourself or others						
4. Home activities						
5. Learning/ education/ self-help activities						
6. Leisure/hobby/ entertainment activities						
7. Shopping activities						
8. Work activities						

4. Imagine that something happened to you (e.g., broke a bone, got sick, lost your memory). If you had to choose between being moved to a care facility (e.g., nursing home, assisted living facility, rehabilitation facility) or remaining in your home and having to use a robot to assist you, which would you choose?

☐1 Remain living in home and use a robot

☐2 Move to a care facility and not use a robot

☐3 Don't know

4a. Would you trust a robot to take care of you in this situation? Please circle your answer on the scale below:

Not Trust	1	2	3	4	5	**Trust**

4b. What would influence your decision about how much to trust a robot to take care of you in this situation?

Section IV. Demographics and Health

INSTRUCTIONS: In this section we would like to know more about you. Please answer the following questions by placing a check in the appropriate box for each question or by writing your answer in the space provided. All of your answers will be treated anonymously. If there is a question you do not wish to answer, please just leave it blank and go on to the next question.

1. Gender: Male ☐1 Female ☐2

2. Age: __________

3. What is your highest level of education?

☐1 No formal education

☐2 Less than high school graduate

☐3 High school graduate/GED

☐4 Vocational training

☐5 Some college/Associate's degree

☐6 Bachelor's degree (BA, BS)

☐7 Master's degree (or other post-graduate training)

☐8 Doctorial degree (PhD, MD, EdD, DDS, JD, etc.)

4. Do you consider yourself Hispanic or Latino?

☐1 Yes

☐2 No

4a. If "Yes", would you describe yourself:

☐1 Cuban

☐2 Mexican

☐3 Puerto Rican

☐4 Other (please specify) ________________

5. How would you describe your primary racial group?

☐1 No primary group

☐2 White Caucasian

☐3 Black/African American

☐4 Asian

☐5 American Indian/Alaska Native

☐6 Native Hawaiian/Pacific Islander

☐7 Multi-racial

☐8 Other (please specify) ____________________

6. In which type of housing do you live?

☐1 Residence hall/College dormitory

☐2 House/Apartment/Condominium

☐3 Senior housing (independent)

☐4 Assisted living

☐5 Nursing home

☐6 Relative's home

☐7 Other (please specify) ____________________

7. Do you live by yourself?

☐1 Yes

☐2 No

7a. If No, how many other people live in your home? _______________

8. What is your primary occupational status? (Check <u>one</u>)

☐1 Work full-time

☐2 Work part-time

☐3 Student

☐4 Homemaker

☐5 Retired

☐6 Volunteer worker

☐7 Seeking employment, laid off, etc.

☐8 Other (please specify) ___________________

9. What is your primary occupation? ___________________

<u>If retired</u>:

9a. What was your primary occupation? __________________

9b. What year did you retire? ____________________

10. Which category best describes your yearly household income. Do not give the dollar amount, just check the category:

☐1 Less than $25,000

☐2 $25,000-$49,999

☐3 $50,000-$74,999

☐4 $75,000-$99,999

☐5 $100,000 or more

☐6 Do not know for certain

☐7 Do not wish to answer

Health Information

1. In general, would you say your health is:

☐1 Poor

☐2 Fair

☐3 Good

☐4 Very Good

☐5 Excellent

2. How often do health problems stand in the way of doing the things you want to do?

☐1 Never

☐2 Seldom

☐3 Sometimes

☐4 Often

☐5 Always

3. The following items are activities you might do during a typical day. Does your health now limit you in these activities? Check one box for each type of activity.

	Not limited at all1	**Limited a little**2	**Limited a lot**3
a. Bathing or dressing yourself			
b. Bending, kneeling, or stooping			
c. Climbing **one** flight of stairs			
d. Lifting or carrying groceries			
e. Moderate household activities such as pushing vacuum cleaner, scrubbing tiles, or washing windows			
f. Vigorous activities such as running, pushing lawn mower, or participating in strenuous sports (e.g., swimming laps)			

4. For each of the following conditions please indicate if you have ever had the condition in your life, have the condition now, or never had the condition. Check one box for each condition.

	Never1	**Now**2	**In your lifetime**3
a. Arthritis			
b. Diabetes			
c. Heart Disease			
d. Hearing impairment			
e. Vision impairment not correctable by glasses/contacts			
f. Stroke			
g. Cancer (other than skin cancer)			
h. Other significant illness (please list)			

5. How often do you typically take prescription medication?

- ☐1 Never
- ☐2 Seldom (a few times per year)
- ☐3 Sometimes (at least once a month)
- ☐4 Often (at least once a week)
- ☐5 Always (everyday)

6. How many prescription medications are you currently taking on a typical day?

____

THIS COMPLETES THE QUESTIONNAIRE. Please take a moment to review your answers. Please make sure that you have completed all of the questions you wanted to.

When you are done with the questionnaire, please place it in the provided envelope along with the blue sheet. Please mail it to us by April 1st, 2008.

If you would like to enter the sweepstakes for one of fifty $50 gift cards and/or receive a summary of the results of the study, please fill out sweepstakes entry form. Please mail the sweepstakes entry form in the provided envelope and mail it to us by April 1st, 2008.

If you have any questions please contact the principle investigators:

Dr. Arthur D. Fisk
(404) 894-6066
or
Dr. Wendy A. Rogers
(404) 894-6775

Thank you again for your participation. We appreciate your time and willingness to help. As a reminder, all of the information you provided us with will be kept anonymous. Any identifying information will be separated from your questionnaire.

THANK YOU!!!

APPENDIX D: CORRELATIONS BETWEEN ACTIVITY LIMITATIONS DUE TO HEALTH

Correlations between self-reported activity limitations due to health[1]

Activity	*1*	*2*	*3*	*4*	*5*	*6*
1. Bathing/dressing	--	.312**	.417**	.379**	.338**	.221*
2. Bending/kneeling/stooping		--	.622**	.641**	.669**	.610**
3. Climbing flight of stairs			--	.542**	.632**	.513**
4. Lifting bag of groceries				--	.726**	.522**
5. Moderate household activities					--	.591**
6. Vigorous activities						--

[1]Spearman correlation
** significant at the .01 level (two-tailed)

APPENDIX E: CORRELATIONS BETWEEN ITEMS IN THE HEALTH-COMPLEXITY SCALE

Correlations between items in the health-complexity scale

Activity	*1*	*2*	*3*	*4*	*5*	*6*
4. General health[1]	--	.436**	.444**	.243**	.198**	.305**
5. Freq. health limitations[2]		--	.641**	.363**	.206**	.401**
6. Limitations in activities[3]			--	.345**	.198*	.324**
7. Medical conditions[4]				--	.406**	.558**
8. Freq. prescription medications					--	.562**
9. Num. prescription medications						--

[1]reverse-scored (1 = excellent to 5 = poor)
[2]participants' indication of the frequency that their health problems stand in the way of them doing what they want to do (1 = never to 5 = always)
[3]Sum of six activity categories
[4]Sum of seven medical conditions
* significant at the .05 level (two-tailed)
** significant at the .01 level (two-tailed)

APPENDIX F: CORRELATION BETWEEN FREQUENCIES OF TECHNOLOGY USE IN PAST YEAR[1]

Technology	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
1. Answering mach.	--	-.06	.01	.06	-.05	.08	.13	-.03	.10	.11	.17	.03	.03	.18	-.17	-.02	.01	.11	**.37**	.11
2.ATM		--	**.33**	**.38**	**.27**	**.39**	**.23**	**.33**	.16	.03	**.30**	**.37**	**.39**	.15	**.31**	-.03	**.34**	**.22**	-.12	.14
3. CD/DVD			--	**.29**	.20	**.36**	**.27**	**.45**	**.21**	.02	**.21**	**.38**	**.50**	.04	**.35**	.12	**.48**	**.23**	.02	.15
4. Cell phone				--	**.28**	**.39**	.18	**.39**	.19	-.04	**.23**	.15	**.40**	**.33**	.20	-.06	**.22**	.10	.10	**.26**
5. Computer game					--	**.28**	-.04	**.30**	.06	-.04	.20	**.24**	**.48**	.09	.20	-.01	**.34**	.11	.02	.12
6. Credit card						--	**.24**	**.33**	.13	-.11	**.26**	**.29**	**.50**	**.35**	**.24**	-.01	**.28**	.10	.15	.17
7. Cruise control							--	.19	.05	-.01	**.26**	**.21**	.08	.09	.07	.05	.06	.20	.01	.05
8. Digital photo.								--	.19	-.07	**.40**	**.46**	**.55**	.11	.45	-.06	**.42**	**.29**	-.09	.12
9. Fitness device									--	.10	**.23**	.16	.15	.09	**.25**	.01	.10	.08	.06	.19
10. Home med. dev.										--	.03	.10	-.01	.09	-.06	.06	.08	.12	.09	.02
11. In-car nav.											--	**.38**	**.28**	.13	.18	-.14	**.23**	.20	.03	.03
12. In-store kiosk												--	**.39**	.04	**.31**	-.07	**.37**	**.25**	-.05	.11
13. Internet/e-mail													--	.21	**.33**	-.05	**.68**	.19	.03	.15
14. Microwave oven														--	.01	-.01	.04	.02	**.25**	**.35**
15. Mp3/iPod															--	-.01	**.41**	**.45**	**-.26**	.15
16. Non-digital cam.																--	.03	.06	.08	-.04
17. PC/laptop																	--	**.23**	-.05	.10
18. PDA																		--	.08	.13
19. Telephone																			--	.18
20. Washing mach.																				--

[1] significant at the .05 level (two-tailed) noted by underline; significance at the .01 level (two-tailed) noted in bold

APPENDIX G: CORRELATIONS BETWEEN ITEMS IN THE ROBOT EXPERIENCE SCALE

Correlations between items in the robot experience scale

Robot	*1*	*2*	*3*	*4*	*5*	*6*
1. Robot factory machine	--	.455**	.326**	.305**	.427**	.346**
2. Robot lawn mower		--	.593**	.500**	.279**	.460**
3. Robot mopping device			--	.444 **	.395**	.563**
4. Robot security guard				--	.209**	.216**
5. Robot toy					--	.396**
6. Robot vacuum cleaner						--

** significant at the .01 level (two-tailed)

APPENDIX H: CORRELATIONS BETWEEN ITEMS IN THE IMPORTANCE-OF-TECHNOLOGY SCALE

Correlations between items in the importance-of-technology scale

Activity	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. Comm. activities	--	.521**	.423**	.329**	.383**	.241**	.268**	.339**
2. Financial activities		--	.463**	.370**	.497**	.348**	.529**	.317**
3. Health care activities			--	.503**	.494**	.340**	.324**	.422**
4. Home activities				--	.522**	.463**	.431**	.298**
5. Learning activities					--	.522**	.365**	.411**
6. Leisure activities						--	.467**	.249**
7. Shopping activities							--	.343**
8. Work activities								--

** significant at the .01 level (two-tailed)

APPENDIX I: CODING SCHEME FOR ROBOT WRITTEN DESCRIPTIONS AND DRAWINGS

Robot Descriptions and Drawings

1.0 Appearance
- 1.1 Overall Appearance
  - 1.1.1 Human-like appearance
    - 1=Not at all
    - 2=To a limited extent
    - 3=To a moderate extent
    - 4=To a large extent
    - 5=Explicitly mentioned
  - 1.1.2=Machine-like/mechanical appearance
    - 1=Not at all
    - 2=To a limited extent
    - 3=To a moderate extent
    - 4=To a large extent
    - 5=Explicitly mentioned
  - 1.1.3 Looks like animal (i.e. biological, but not human)
    - 1=Not at all
    - 2=To a limited extent
    - 3=To a moderate extent
    - 4=To a large extent
    - 5=Explicitly mentioned

- 1.2 Height
  - 1=Much shorter than a human of average height (approx. < 3 ft)
  - 2=Slightly shorter than a human of average height (approx. 3ft>=<5 ft)
  - 3=Same height as a human of average height (approx. 5 ft><6 ft)
  - 4=Taller than a human
  - 5=Height changes or multiple heights
  - 6=Other
  - 7=Not mentioned/unable to tell

2.0 Does the robot have a head?
- 1=yes
- 2=no
- 3=not sure

3.0 Does the robot have a face?
- 1=yes

2=no
3=not sure

3.1 Does the robot have eyes?
1=yes
2=no
3=not sure

3.2 Does the robot have ears?
1=yes
2=no
3=not sure

3.3 Does the robot have a nose?
1=yes
2=no
3=not sure

3.4 Does the robot have a mouth?
1=yes
2=no
3=not sure

4.0 Does the robot have biological-looking arms (e.g., human-like or animal-like arm)?
1=yes
2=no
3=not sure

4.1 How many biological-looking arms? (enter number or 0 if none)

5.0 Does the robot have mechanical "arms" (non-biological; e.g., very mechanical looking extensions from its body)?
1=yes
2=no
3=not sure

5.1 How many mechanical "arms"? (enter number or 0 if none)

6.0 Does the robot have antennae?
1=yes
2=no
3=not sure

7.0 Does the robot have features that appear to let it move around?
1=yes

2=no
3=not sure

7.1 Does the robot have legs/feet?
1=yes
2=no
3=not sure

7.1.1 How many legs/feet? (enter number or 0 if none)

7.2 Does the robot have wheels?
1=yes
2=no
3=not sure

7.3 Is the robot on treads or tracks?
1=yes
2=no
3=not sure

7.4 What other features (not legs, wheels, tracks, or treads) does the robot have that appear to let the robot move around?

8.0 Does the robot have interaction features (e.g. buttons, screen, speakers, cameras)?
1=yes
2=no
3=not sure

8.1 Does the robot have buttons?
1=yes
2=no
3=not sure

8.2 Does the robot have a screen?
1=yes
2=no
3=not sure

8.3 What other interaction features (besides buttons and screens) does the robot have?

9.0 Is the robot wearing clothes?
1=yes
2=no
3=not sure

10.0 Does the robot have a gender?
1=appears male
2=appears female
3=no gender (e.g., very mechanical looking, box-shaped)
4=not sure/too ambiguous

11.0 What other items are drawn with the robot
11.1 Cleaning supplies
1=yes
2=no
3=not sure
11.2 Interchangeable parts
1=yes
2=no
3=not sure
11.3 Batteries
1=yes
2=no
3=not sure
11.4 List other items drawn with the robot

12.0 Tasks Mentioned

12.1 Aiding/Assisting Tasks/Physical Tasks that Help User (e.g., reaching tasks, lifting tasks, lifting person if he/she has fallen)
1=Mentioned
2=Not mentioned
12.2 Cleaning/Organizing /Chore-Type Tasks
1=Mentioned
2=Not mentioned
12.3 Cooking Tasks
1=Mentioned
2=Not mentioned
12.4 Entertainment Tasks (e.g., dancing, singing, or telling jokes)
1=Mentioned
2=Not mentioned
12.5 Health-Related Tasks (e.g., health monitoring, medication reminder, medication administration, promotion of health-related activities such as exercising)
1=Mentioned
2=Not mentioned
12.6 Home maintenance/Repairs (e.g., hammering nails into walls)
1=Mentioned
2=Not mentioned
12.7 Interactive Activities (e.g., playing sports with user, playing chess with user)
1=Mentioned

2=Not mentioned

12.8 Providing Company/Conversation

1=Mentioned

2=Not mentioned

12.9 Providing Information (e.g. news, weather forecast)

1=Mentioned

2=Not mentioned

12.10 Security Tasks (e.g., monitoring home, defending against intruders)

1=Mentioned

2=Not mentioned

12.11 Serving Tasks (e.g., bringing a cup of water; tasks user does not have difficulty performing him/herself)

1=Mentioned

2=Not mentioned

12.12 Taking Care of/Feeding pets

1=Mentioned

2=Not mentioned

12.13 Working with Other Machines/Devices

1=Mentioned

2=Not mentioned

12.14 Other Tasks

1=Mentioned

2=Not mentioned

13.0 Method of Control

13.1 Programmed

1=General

2=Pre-programmed (e.g., not by user)/automatic

3=User-programmed

4=Both pre- and user-programmed

5=Not mentioned

13.2 Direct Human Control

13.2.1 Input/Interface on Robot (e.g., touch screen, buttons)

1=Mentioned

2=Not mentioned

13.2.2 Remote Control/ Game Controller

1=Mentioned

2=Not mentioned

13.2.3 Teaching/Training /Robot Learns (e.g., robot shown what to do)

1=Mentioned

2=Not mentioned

13.2.4 Voice Activation/Commands

1=Mentioned

2=Not mentioned

13.2.5 Other

1=Mentioned

2=Not mentioned

13.3 Sensors (i.e., robot has sensors which allow it to perform certain functions, navigate, or gain knowledge about its environment)

1=Mentioned

2=Not mentioned

14.0 Is there anything else about the robot that was not captured by the previous categories?

APPENDIX J: FACTOR CORRELATION MATRIX, STRUCTURE MATRIX, AND COVARIANCE MATRICES FOR THE THREE ROBOT CHARACTERISTIC FACTORS

Factor correlation matrix for robot characteristic factors

Factor	*1*	*2*	*3*
1	--	.439	-.271
2		--	-.013
3			--

Structure matrix for robot characteristic factors

Item	Factor 1	2	3
reliable	.800		
efficient	.770		
helpful	.755		
coordinated	.741		
precise	.724		
useful	.715		-.421
safe	.683		
trustworthy	.654		
agreeable	.618		
confident	.603		
calm	.587		
sturdy	.569		
quiet	.551		
dynamic	.499	.446	
serious	.492		
expressive	.427	.765	
friendly	.547	.757	
compassionate	.414	.752	
unfeeling		-.718	
creative	.431	.691	
playful		.687	
lifelike	.456	.663	
motivated	.578	.647	
unimaginative		-.614	
unsocial		-.609	
talkative		.562	
dull		-.535	
boring		-.455	
artificial		-.402	
unpredictable			.705
chaotic			.704
wasteful			.677
clumsy	-.471		.657
risky			.651
demanding			.576
lazy			.548
selfish			.544
nervous			.524
careless			.505
breakable			.471
hostile			.462

Covariance matrices for robot characteristic factors

Group	*Robot Characteristic Factor*	*1*	*2*	*3*
Younger adults	1. Performance-oriented traits	.292	.265	-.122
	2. Socially-oriented traits	.265	.955	-.067
	3. Non-productive traits	-.122	-.067	.194
Older adults	1. Performance-oriented traits	.639	.308	-.184
	2. Socially-oriented traits	.308	.931	-.109
	3. Non-productive traits	-.184	-.109	.185

APPENDIX K: CORRELATION MATRIX FOR ROBOT ROLE ITEMS, STRUCTURE MATRIX FOR ROLE FACTORS, AND FACTOR CORRELATION MATRIX FOR ROLE FACTORS

Factor correlation matrix for robot role factors

Factor	*1*	*2*	*3*
1	--	.523	.338
2		--	.521
3			--

Structure matrix for robot role factors

	Factor		
Item	**1**	**2**	**3**
friend	.812	.731	.527
machine	-.805		
human	.741	.628	.451
appliance	-.580		
assistant		.736	
teammate	.514	.671	.468
servant		.518	
pet		.428	.599
toy			.479

Correlations between robot role items

Role		*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1.	Appliance	--	-.043	-.409**	-.337**	.568**	-.179*	.036	-.100	.217**
2.	Assistant		--	.421**	.364**	-.079	.172*	.436**	.464**	-.145
3.	Friend			--	.759**	-.466**	.391**	.223**	.638**	-.059
4.	Human				--	-.492**	.366**	.206**	.497**	-.063
5.	Machine					--	-.115	.195*	-.275**	.278**
6.	Pet						--	.242**	.394**	.226**
7.	Servant							--	.236**	.008
8.	Teammate								--	-.009
9.	Toy									--

* significant at the .05 level (two-tailed)
** significant at the .01 level (two-tailed)

APPENDIX L: COMPONENT CORRELATION MATRIX, STRUCTURE MATRIX, AND CORRELATION MATRIX FOR TECHNOLOGY ACCEPTANCE MODEL (TAM) ITEMS

Component correlation matrix for TAM components

Factor	*1*	*2*
1	--	.599
2		--

Structure matrix for TAM components

	Component	
Item	**1**	**2**
Easy to use	.909	.544
Controllable	.887	.495
Easy to become	.866	.577
Easy to learn	.862	.498
Increase productivity	.489	.936
Effectiveness	.606	.918
Increase performance	.508	.911
Useful	.694	.807

Correlations between technology acceptance model (TAM) items

Role	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. Increase performance	--	.791**	.762**	.672**	.440**	.506**	.432**	.446**
2. Increase productivity		--	.833**	.672**	.414**	.480**	.405**	.461**
3. Effectiveness			--	.688**	.504**	.562**	.523**	.552**
4. Useful				--	.539**	.596**	.562**	.640**
5. Easy to learn					--	.774**	.628**	.672**
6. Easy to become skillful						--	.651**	.673**
7. Controllable							--	.651**
8. Easy to use								--

** significant at the .01 level (two-tailed)

APPENDIX M: CORRELATION MATRIX FOR ITEMS IN ATTITUDINAL AND INTENTIONS ACCEPTANCE SCALES

Correlations between items in attitudinal and intention acceptance scales

Acceptance	*Item*	*1*	*2*	*3*	*4*	*5*	*6*
Attitudinal	1. Good	--	.761**	.750**	.596**	.586**	.551**
	2. Favorable		--	.824**	.489**	.510**	.493**
	3. Positive			--	.492**	.529**	.482**
Intentional	4. Strong Intention				--	.886**	.878**
	5. Likely					--	.888**
	6. Buy it						--

** significant at the .01 level (two-tailed)

APPENDIX N: FACTOR CORRELATION MATRIX AND STRUCTURE MATRIX FOR ROBOT TASK FACTORS

Factor correlation matrix for robot task factors

Factor	*1*	*2*	*3*
1	--	.668	.465
2		--	.429
3			--

Structure matrix for robot task factors

	Factor		
Item	**1**	**2**	**3**
Teach hobby	.770	.429	
Give information	.754	.483	
Motivate to	.744	.584	
Help stick to diet	.724	.667	
Conversation	.677		.422
Medication	.656	.590	
Teach skill	.649	.626	
Play games	.625	.470	
Warn about danger	.423	.741	
Scare intruder	.435	.679	
Teach to use	.664	.669	
Inform doctor	.505	.586	
Bringt hings			.796
Make meals	.504	.462	.690
Housework			.556

APPENDIX O: CODING SCHEME FOR TRUST IN ROBOT SCENARIO OPEN-ENDED QUESTION

Influences on Trust in Robot

1.0 Ease of Use
    1=Mentioned
    2=Not mentioned
2.0 Evidence of Performance
    2.1 Capability of robot to handle unexpected events
        1=Mentioned
        2=Not mentioned
    2.2 First-hand experience
        1=Mentioned
        2=Not mentioned
    2.3 Physical capability of robot
        1=Mentioned
        2=Not mentioned
    2.4 Reliability
        1=Mentioned
        2=Not mentioned
    2.5 Robot intelligence/knowledge
        1=Mentioned
        2=Not mentioned
    2.6 Robot limitations/errors
        1=Mentioned
        2=Not mentioned
    2.7 Second-hand experience
        1=Mentioned
        2=Not mentioned
3.0 Advancements in Technology/Feasibility
    1=Mentioned
    2=Not mentioned
4.0 Human Likeness
    4.1 Emotion/personality
        1=Mentioned
        2=Not mentioned
    4.1 Physical likeness
        1=Mentioned
        2=Not mentioned
5.0 My Condition/Ability to Take Care of Myself
    1=Mentioned
    2=Not mentioned
6.0 Need more Information about Robots

Company information
General information

7.0 Price
1=Mentioned
2=Not mentioned

8.0 Robots cannot replace humans
1=Mentioned
2=Not mentioned

9.0 Trust in Human Care/Condition of Care Facility
1=Mentioned
2=Not mentioned

10.0 Nothing/Don’t Know
1=Mentioned
2=Not mentioned

11.0 Other
1=Mentioned
2=Not mentioned

APPENDIX P: DEMOGRAPHICS AND HEALTH QUESTIONNAIRE FOR INTERVIEW

Please answer the following questions. All of your answers will be treated confidentially. Any published document regarding these answers will not identify individuals with their answers. **If there is a question you do not wish to answer, please just leave it blank and go on to the next question.** Thank you in advance for your help.

Demographics Questionnaire

Gender: Male ☐1 **Female** ☐2 **Date of Birth:** __ __ / __ __ / __ __ **Age:** _______

1. What is your highest level of education?

☐1 No formal education
☐2 Less than high school graduate
☐3 High school graduate/GED
☐4 Vocational training
☐5 Some college/Associate's degree
☐6 Bachelor's degree (BA, BS)
☐7 Master's degree (or other post-graduate training)
☐8 Doctoral degree (PhD, MD, EdD, DDS, JD, etc.)

2. Current marital status (check one)

☐1 Single
☐2 Married
☐3 Separated
☐4 Divorced
☐5 Widowed
☐6 Other (please specify) _________________

3. Do you consider yourself Hispanic or Latino?

☐1 Yes
☐2 No

3 a. If "Yes", would you describe yourself:

☐1 Cuban
☐2 Mexican
☐3 Puerto Rican
☐4 Other (please specify) ________________

4. **How would you describe your primary racial group?**

☐1 No Primary Group
☐2 White Caucasian
☐3 Black/African American
☐4 Asian
☐5 American Indian/Alaska Native
☐6 Native Hawaiian/Pacific Islander
☐7 Multi-racial
☐8 Other (please specify) ______________________

5. **In which type of housing do you live?**

☐1 Residence hall/College dormitory
☐2 House/Apartment/Condominium
☐3 Senior housing (independent)
☐4 Assisted living
☐5 Nursing home
☐6 Relative's home
☐7 Other (please specify) ________________

6. **Which category best describes your yearly household income. Do not give the dollar amount, just check the category:**

☐1 Less than $5,000
☐2 $5,000 - $9,999
☐3 $10,000 - $14,999
☐4 $15,000 - $19,999
☐5 $20,000 - $29,999
☐6 $30,000 - $39,999
☐7 $40,000 - $49,999
☐8 $50,000 - $59,999
☐9 $60,000 - $69,999
☐10 $70,000 - $99,999
☐11 $100,000 or more
☐12 Do not know for certain
☐13 Do not wish to answer

7. **Is English your primary language?**

☐1 Yes
☐2 No

7 a. If "No", What is your primary language? ________________________

8. What is your primary mode of transportation? (Check one)

☐1 Drive my own vehicle
☐2 A friend or family member takes me to places I need to go
☐3 Transportation service provided by where I live
☐4 Use public transportation (e.g., bus, taxi, subway, van services)

Occupational Status

9. **What is your primary occupational status? (Check one)**

☐1 Work full-time
☐2 Work part-time
☐3 Student
☐4 Homemaker
☐5 Retired
☐6 Volunteer worker
☐7 Seeking employment, laid off, etc.
☐8 Other (please specify) ____

10. **Do you currently work for pay?**

☐1 Yes, Full-time
☐2 Yes, Part-time
☐3 No

10 a. If "Yes", what is your primary occupation? ______________________________

<u>If retired:</u>

11. What was your primary occupation? ___________________________

12. What year did you retire? ______________________

Health Information

1. **In general, would you say your health is:**

☐1	☐2	☐3	☐4	☐5
Poor	Fair	Good	Very good	Excellent

2. **Compared to other people your own age, would you say your health is:**

☐1	☐2	☐3	☐4	☐5
Poor	Fair	Good	Very good	Excellent

3. **How satisfied are you with your present health?**

☐1	☐2	☐3	☐4	☐5
Not at all satisfied	Not very satisfied	Neither satisfied nor dissatisfied	Somewhat satisfied	Extremely satisfied

4. **How often do health problems stand in the way of your doing the things you want to do?**

☐1	☐2	☐3	☐4	☐5
Never	Seldom	Sometimes	Often	Always

5. **The following items are about activities you might do during a typical day. Does your health now limit you in these activities? Check one box for each type of activity.**

	Limited a lot$_1$	**Limited a little$_2$**	**Not limited at all$_3$**
a. Bathing or dressing yourself			
b. Bending, kneeling, or stooping			
c. Climbing **one** flight of stairs			
d. Climbing **several** flights of stairs			
e. Lifting or carrying groceries			
f. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf			
g. Vigorous activities, such as running, lifting heavy objects, or participating in strenuous sports (e.g., swimming laps)			
h. Walking **more than a mile**			
i. Walking **one block**			
j. Walking **several blocks**			

6. **Are you on post-menopausal estrogen replacement therapy?**

☐[1] Yes ☐[2] No ☐[3] Not applicable

7. **For each of the following conditions please indicate if you have ever had that condition in your life, have the condition now at this time or never had the condition. Check <u>one</u> box for each condition.**

Condition	In your lifetime[1]	Now[2]	Never[3]
a. Arthritis			
b. Asthma or Bronchitis			
c. Cancer (other than skin cancer)			
d. Diabetes			
e. Epilepsy			
f. Heart Disease			
g. Hearing Impairment			
h. Hypertension			
i. Stroke			
j. Vision Impairment			
k. Other significant illnesses (please list)			

Medication Usage Details

Please list all medical products that you are currently taking. Include medicinal herbs, vitamins, aspirin, antacid, nasal spray, laxatives, etc., as well as prescription medications (copy names from label if possible). This information will be completely confidential.

EXAMPLE

Name of Medication: ______________Zarontin________________________________

Reason for taking:____epilepsy___ Dosage (ea. time taken):_______500 mg________

How often do you take the medication? (circle one)

daily every other day weekly as needed

On days that you take the medication, how many times per day do you take it? ______3___

What time of day do you take the medication? morning, afternoon, evening_________

How long you have been taking the medication? _________5 years_________________Does this medication cause any problems? ___________makes me sleepy______________

1. Name of Medication: ____

Reason for taking:______________________ Dosage (ea. time taken):________

How often do you take the medication? (circle one)

daily every other day weekly as needed

On days that you take the medication, how many times per day do you take it? _________

What time of day do you take the medication? ___________________________________

How long you have been taking medication? ____________________________

Does this medication cause any problems? _____________________________________

____

APPENDIX Q: INTERVIEW SCRIPT

Script for Interview

INTRODUCTION

Hello and welcome to this interview being conducted by the Human Factors and Aging Group at Georgia Tech. Thank you for taking the time to come and talk with me. We conduct research with adults of all ages to understand people's perceptions about technology. Most of our projects are funded by the National Institutes of Health.

The things we learn from interviews like this one help us to focus on important issues that are related to people's perceptions of technology. We can use this information to recommend design changes for systems and products or to develop improved instructions.

Today, I would like to discuss your expectations of and attitudes toward the idea of having a robot in your home. I am interested in what you imagine a robot in your home to look like, act like and do in your home.

First I will explain the informed consent.

INFORMED CONSENT

I have given you two copies of the consent form, one copy is for us and the other is for your own records. Note that before you sign the consent forms, please make sure that you feel comfortable with participating today. If you decide for any reason that you are not able to participate today, let me know at any time. If you do not have any questions and you still wish to continue, you may sign the consent forms.

STRUCTURED INTERVIEW

Now, we will move on to the structured interview. Before we begin, you should understand that there are no right or wrong answers, only different opinions. That's why this kind of interview is so valuable to us, it enables us to learn a lot about the different kinds of opinions that people have.

The session will last about one hour. If there is something that I can do to make you more comfortable, like get you a different chair or get you something to drink, please let me know. Also, before we begin, if you need to use the restroom, please do so now.

Do you have any questions before we begin the interview?

Ok, I'm going to turn on the tape recorder and begin recording now.

Main Interview Script

Today I am going to ask you about robots. I am interested in your opinions of robots and what *you* think about them. Because I am interested in what *you* think, there are no right or wrong answers. If you do not understand a question, please tell me and I will try to clarify what I am asking. If you do not want to answer a question, please tell me and I will move on to the next question. I care very much about what you have to say. Because I will be tape-recording the interview, please speak up. I do not want to miss anything that you have to say. Ok, let's begin.

1. In your own words, what is a robot?

    1a. How did you come up with your definition of a robot?

        -(if movie, book, or T.V. show). Can you be specific about which character you were thinking about?

        -(if from experience) Can you be more specific about your experience with this type of robot?

    1b. How is a robot different from other types of technology?

Now I would like you to think about your home.

2. Could you please describe your home to me, as if you were giving me a short tour? For example you could describe the number of rooms in your home and the general layout of your home.

I would like you to think about a robot being put in your home. Take a minute to imagine what this robot would look like, behave like, and do in your home. Also think about how you would interact with the robot, if at all. You may close your eyes if this will help you to imagine a robot in your home. (1 minute later): Do you have an image in your mind about what a robot in your home would be like or do you need more time?

3. What types of tasks would the robot in your home do?

    3a. Why would you want the robot in your home to do the tasks you mentioned?

    3b. How often would the robot do the tasks you mentioned?

    3c. Would you want the robot to do the tasks you mentioned with or without you and Why?

    3d. Where would you be when the robot does the tasks you mentioned?

    3e. How does the robot know what it needs to do?

    3f. Can the robot do something without your approval? If so, what?

    3g.What does the robot do when it is done?

4. Please keep thinking about a robot that you imagined in your home. I would like you to answer some questions about what you imagine this robot would look like.

    4a. What do you think a robot in your home would look like?

        - (if not mentioned already)

            -What is the size of the robot?

            -What is the robot made of?

            -Does the robot move around or stay in one place? If it moves around, what enables it to move around?

            -What is the shape of the robot?

            -(if describe face) Can you be more specific about what the robot's face looks like.

    4b. Why do you think the robot in your home would look this way?

5. Please keep thinking about a robot that you imagined in your home. I would like you to describe to what you imagine a typical day with the robot would be like.

5a. Can you tell me what a typical day with the robot you imagined in your home would be like?

6. Now I would like to ask you some more general questions about the robot you imagine in your home.

6a. Where would the robot be allowed in your home?

6b. Is there anywhere the robot would not be allowed in your home?

6c. How often would you interact with the robot?

6d. Is there anyone else besides you who would use the robot?

6e. (If other people will use robot) Would _________ use the robot in the same way or in a different way than you do? (If in a different way): How would __________use the robot that is different from the way you would use it?

6f. What does the robot do if guests are over?

6g. What does the robot do when you are not at home for a few hours?

6h. What does the robot do when you are on vacation for a week?

6i. What do you do if the robot makes a mistake?

6j. What do you do if the robot breaks down or stops working?

7. We talked about a robot that performs ____________in your home. Now, I would like you to think about a robot that (if not mentioned):

7a. is used for entertainment

7a.1 What types of things would a robot used for entertainment do in your home?

7a.2 What would a robot used for entertainment in your home look like?

7a.3 How would a robot used for entertainment in your home know what to do?

7a.4 What is your overall opinion of a robot used for entertainment in your home?

7b. I would like you to think about a robot that helps with health-related activities in your home

7a.1 What types of things would a robot used for health-related activities do in your home?

7a.2 What would a robot used for health-related activities in your home look like?

7a.3 How would a robot used for health-related activities in your home know what to do?

7a.4 What is your overall opinion of a robot used for health-related activities in your home?

7c. I would like you to think about a robot that is used for security in your home

7c.1 What types of things would a robot used for security do in your home?

7c.2 What would a robot used for security in your home look like?

7c.3 How would a robot used for security in your home know what to do?

7c.4 What is your overall opinion of a robot used for security in your home?

8. I would like you to think about a robot that you would <u>not</u> enjoy or <u>not</u> want in your home.

8a. What are some negative qualities or characteristics of robots that would make you NOT want a robot in your home?

9. If you were considering getting a robot for your home, what would you want to know about the robot before getting it?

10. Do you think you would need to adjust your lifestyle if you got a robot for your home?

- (*if no*): Why don't you think you would need to adjust your lifestyle if you got a robot for your home?

-(*if yes*): How do you think you would need to adjust your lifestyle if you got a robot for your home?

11. Throughout this interview, I have asked you a lot of questions about robots. Do you feel your opinion or view of robots has changed from the beginning of the interview to now?

12. Is there anything else about robots that you would like to mention?

Thank you, this concludes the interview. I will turn off the tape-recorder now.

Standard follow-up questions:

- Could you please clarify your answer?
- Could you be a little more specific?
- Although you brought up an interesting point, the question was…. (restate question).
- Is there anything else you would like to add?
- What influenced you opinion?

APPENDIX R: EXIT INTERVIEW

Exit Questions

Thank you for participating in the interview. We have just a few more questions to ask you. Please answer the questions below as best you can. If you do not want to answer a question, please leave it blank.

1. Before this interview, had you ever thought about what it would be like to have a robot in your home?

☐1 Yes

☐2 No

2. How easy or difficult was it for you to imagine a robot in your home? Please circle a number from (1 difficult to 5 easy).

1	2	3	4	5
Difficult to Imagine				**Easy to Imagine**

3. What did you do to create an image of a robot in your home? Please check all the boxes that apply.

☐1 I thought of a device, product, or robot that I already own.

What device, product, or robot did you think about?____

☐2 I thought of a fictional robot I remember from a movie, TV show, or book.

What fictional robot did you think of from a movie, TV show, or book?____

What movie, TV show, or book is this fictional robot from?____

☐3 I thought of a robot from a scientific magazine, a scientific journal, or a TV show about real (non-fictional) robots.

What robot were you thinking about from a scientific magazine, scientific journal, or TV show about real robots?____

What scientific magazine, scientific journal, or TV show was this robot from?____

☐4 I thought about what I wanted the robot to do and then imagined a robot that could do those things.

☐5 I pictured my home first (e.g., thought about the rooms in my home) and then imagined a robot in it.

☐6 I was not able to imagine a robot in my home.

☐7 Other ____

____

APPENDIX S: CODING SCHEME FOR ROBOT INTERVIEW

Code System

- 1. Robot Definition
    - 1.1 Mechanical/Electronic Device/Machine
        1. Device or machine
        2. ELECTRONIC Device or machine
        3. MECHANICAL Device or machine
        4. Electronic and Mechanical Device or Machine
        5. Not Mentioned
    - 1.2 Human Likeness
        1. Acts/Functions Like a Human
        2. Looks and Acts Like a Human
        3. Not a Human
        4. Like a Human in Some ways but not like a human in other ways
        5. Other
        6. Not mentioned
    - 1.3 Function
        1. Does tasks/functions, general
        2. Replaces Human
        3. Augments/Assists human
        4. Does whatever human wants it to do
        5. Other
        6. Not mentioned
    - 1.4 Control
        - 1.4.1 Programmed
            1. General
            2. Pre-programmed (not by user)/ Automatic
            3. User-programmed
            4. Both pre- and user-programmed
            5. Not Mentioned
        - 1.4.2. Direct Human Control
            1. Mentioned
            2. Not Mentioned
- 2. Source of Definition
    - 2.1 TV
        1. General
        2. Fiction/Sci-Fi shows
        3. Non-fiction/Scientific shows
        4. TV Advertisements
        5. Other
        6. Not Mentioned
    - 2.2 Movies
        1. General
        2. Fiction/Sci-Fi Movies
        3. Other
        4. Not Mentioned
    - 2.3 Print Media/Books
        1. General
        2. Fictional/Sci-Fi books or print media
        3. Non-fiction/Scientific books or print media
        4. Other
        5. Not Mentioned
    - 2.4 Experience

- 2.4.1 General Experience
  1. First-hand Experience (owning, seeing, using)
  2. Second-hand Experience (hearing/knowing someone who has one)
  3. First- and Second-Hand Experience
  4. Other
  5. Not Mentioned
- 2.4.2 Consumer Robot (i.e., home-based robots)
  1. Mentioned
  2. Not Mentioned
- 2.4.3 Factory/Processing Plant Robots
  1. Mentioned
  2. Not Mentioned
- 2.4.4 Medical Setting Robots (i.e., hospital, dentist office)
  1. Mentioned
  2. Not Mentioned

2.5 Thinking/Imagining
1. General
2. Thinking/imagining how robots function or tasks they perform
3. Thinking/imagining other types of technologies
4. Other
5. Not Mentioned

3. Robot-Technology Differences

3.1 Difference between Robots and Other Technology
1. Differences between robots and other technology
2. No Differences between robots and other technology
3. Don't Know (explicitly states that does not know)
4. Other/Unclear Answer

3.2 More Human-Like than other technology
1. Mentioned
2. Not Mentioned

3.3 Different Types of Tasks than Other Technology
- 3.3.1 More "Human" Tasks
  1. Mentioned
  2. Not Mentioned
- 3.3.2 More Tasks
  1. Mentioned
  2. Not Mentioned
- 3.3.3 More Complicated Tasks
  1. Mentioned
  2. Not Mentioned
- 3.3.4 More Personalized Tasks
  1. Mentioned
  2. Not Mentioned
- 3.3.5 Other Task Differences
  1. Mentioned
  2. Not Mentioned

3.4 Different Control Than Other Technology
- 3.4.1 Programmed
  1. More programmed, general
  2. More pre-programmed (not by user)/automatic
  3. More User-Programmed
  4. Less programmed/less automatic
  5. Not Mentioned
- 3.4.2 More Direct Human Control
  1. More Direct Control
  2. Less Direct Control

3. Not Mentioned

3.5 Other Differences

3.5.1 More Mobile/Physical Entity

1. Mentioned
2. Not Mentioned

3.5.2 More Teachable/Intelligent

1. Mentioned
2. Not Mentioned

3.5.3 Other

1. Mentioned
2. Not Mentioned

4. Robot Tasks

4.1 Robot Tasks

4.1.1 Aiding/Assisting Tasks (i.e., reaching, lifting)

1. Mentioned
2. Not Mentioned

4.1.2 Cleaning/Organizing/Chore-type Tasks

1. Mentioned
2. Not Mentioned

4.1.3 Cooking Tasks

1. Mentioned
2. Not Mentioned

4.1.4 House Repair/Home Maintenance

1. Mentioned
2. Not Mentioned

4.1.5 Providing Company/Conversation

1. Mentioned
2. Not Mentioned

4.1.6 Security Tasks

1. Mentioned
2. Not Mentioned

4.1.. Serving Tasks

1. Mentioned
2. Not Mentioned

4.1.8 Taking care of/feeding pets

1. Mentioned
2. Not Mentioned

4.1.9 Working with other machines/devices

1. Mentioned
2. Not Mentioned

4.1.10 Other

1. Mentioned
2. Not Mentioned

5. Why those tasks?

5.1 Reasons for Tasks

5.1.1 Difficulty doing tasks (i.e., due to physical limitations)

1. Currently Difficult
2. May be difficult in the future
3. Not Mentioned

5.1.2 Disinterest in Tasks/Want to do other Activities/

1. Mentioned
2. Not Mentioned

5.1.3 Tasks Not Currently Getting Done As Needed

1. Mentioned
2. Not Mentioned

5.1.4 Other

1. Mentioned
2. Not Mentioned

6. Task Frequency
  6.1 Task Frequency
    1. As often as Possible/continuously
    2. At least once a day but not continuously
    3. At least once a week but less than once a day
    4. Less than once a week
    5. Only when needed or instructed
    6. Both scheduled and on demand
    7. Schedule depends on specific tasks
    8. Other

7. Robot does tasks with or without user?
  7.1 With/Without User
    1. With user
    2. Without user
    3. Sometimes with and sometimes without
    4. Initially with, then without
    5. No preference
    6. Other
  7.2 Why With?
    1. Have to monitor/don't trust/make sure doing things correctly
    2. Have to be present to command/program/teach robot
    3. Other
    4. Not Mentioned
  7.3 Why Without?
    1. Trust/Don't have to monitor/Automatic
    2. Save time/Want to do own activities
    3. Don't want interference from robot
    4. Other
    5. Not Mentioned

8. Location of Person
  8.1 Location of Person When Robot Performing Tasks
    1. Outside home (away from home, not part of home)
    2. In Home, general
    3. In home, doing own activities (ie reading, watching tv)
    4. Same Location as Robot, watching/monitoring
    5. In home or away from home
    6. Initially in home, then away from home
    7. Other

9. Robot Control
  9.1 Control, General
    9.1.1 Programmed
      1. General
      2. Pre-programmed (not by user)/automatic
      3. User-programmed
      4. Both pre- and user-programmed
      5. Not Mentioned
    9.1.2 Direct Human Control
      1. Mentioned
      2. Not Mentioned
    9.1.3 Don't Know
      1. Mentioned
      2. Not Mentioned
    9.1.4 Other
      1. Mentioned

2. Not mentioned

9.2 User-Directed Control, Specific

9.2.1 General/Ambiguous

1. Mentioned
2. Not Mentioned

9.2.2 Input/Interface on Robot (touch screen, buttons)

1. Mentioned
2. Not Mentioned

9.2.3 Remote Control/Game Controller

1. Mentioned
2. Not Mentioned

9.2.4 Teaching/Training/Robot Learns (it is shown what to do)

1. Mentioned
2. Not Mentioned

9.2.5 Voice Activation/Commands

1. Mentioned
2. Not Mentioned

9.2.6 Other

1. Mentioned
2. Not Mentioned

9.3 Sensors

1. Mentioned
2. Not Mentioned

10. Task Approval

10.1 Tasks Without Approval from User

1. No, general
2. No, robots must only follow commands
3. No, other
4. Yes, general
5. Yes, but only certain tasks or tasks done before
6. Yes, but only for certain situations
7. Yes, other
8. Don't Know
9. Other

11. Robot Activity when Tasks Complete

11.1 Robot Activity When Tasks Complete

11.1.1 Shuts off/Turns off

1. General
2. Automatically (ie turns itself off)
3. User-controlled (ie user turns it off)
4. Either automatically or user controlled
5. Not mentioned

11.1.2 Stands by/Rests/Sleeps (not off but not working)

1. Mentioned
2. Not Mentioned

11.1.3 Goes to Specific Location (garage, closet, out of way)

1. Mentioned
2. Not Mentioned

11.1.4 Gets Recharged

1. Mentioned
2. Not Mentioned

11.1.5 Other

1. Mentioned
2. Not Mentioned

12. Robot Appearance

12.1 Overall Appearance

1. Human-like appearance (ie Very human-like)
2. Characteristics of both a human and a machine/appliance
3. Machine-like/Mechanical (ie any shape that isn't human)
4. Looks like existing machine/appliance
5. Looks like robot/character from fictional movie
6. Looks like an animal
7. Other
8. Not Mentioned

12.2 Height
1. Much shorter than human of avg height (approx. < 3 ft)
2. Slightly shorter than a human of avg height (approx 3-5 ft)
3. Same height as human of avg height (approx 5-6 ft)
4. Taller than a human
5. Height changes or multiple heights
6. Other
7. Not Mentioned

12.3 Head and Facial Features
12.3.1. Head
1. General
2. Human-like
3. Machine-like
4. No head (explicitly stated that robot does not have a head)
5. Other
6. Not Mentioned

12.3.2. Face
1. General
2. Human-like
3. Machine-like
4. No Face
5. Other
6. Not Mentioned

12.3.3. Eyes
1. General
2. Human-like
3. Machine-like
4. No eyes
5. Other
6. Not Mentioned

12.3.4. Mouth
1. General
2. Human-like
3. Machine-like
4. No Mouth
5. Other
6. Not Mentioned

12.3.5 Nose
1. General
2. Human-like
3. Machine-like
4. No Nose
5. Other
6. Not Mentioned

12.4 Arms and Hands (Appendages)
12.4.1. Arms
1. General
2. Human-like (2 arms)

3. Machine-like (eg. retractable, extendable)
4. No arms
5. Other
6. Not Mentioned

12.4.2. Hands/Fingers
1. General
2. Human-like
3. Machine-like
4. No Hands
5. Other
6. Not Mentioned

12.5 Mobility
1. Moves around, general
2. Has legs, walks like human
3. Has wheels/tread/anything other than legs
4. Has legs and/or wheels/treads
5. Moves, other
6. Stays in one place
7. Other
8. Not Mentioned

12.6 Material
12.6.1. Metal
1. Mentioned
2. Not Mentioned

12.6.2. Plastic
1. Mentioned
2. Not Mentioned

12.6.3 Cloth/Cushioning
1. Mentioned
2. Not Mentioned

12.6.4. Other Material
1. Mentioned
2. Not Mentioned

12.7 Gender
1. Feminine
2. Masculine
3. Neither feminine or masculine
4. Not Mentioned

12.8 Interface
1. Mentioned
2. Not Mentioned

13. Reasons for Appearance
13.1 Reasons for Appearance
13.1.1 Robots Depicted in Media
1. Mentioned
2. Not Mentioned

13.1.2 Matches Functionality
1. Mentioned
2. Not Mentioned

13.1.3 More Friendly/Less Hesitation in Using/User-Friendly
1. Mentioned
2. Not Mentioned

13.1.4 Previous Experience
1. Mentioned
2. Not Mentioned

13.1.5 Imagination

1. Mentioned
2. Not Mentioned

13.1.6 Don't Want it to have a different appearance
1. Mentioned
2. Not Mentioned

13.1.7 Don't Know
1. Mentioned
2. Not Mentioned

13.1.8 Other
1. Mentioned
2. Not Mentioned

14. Typical Day with Robot

14.1 Activation
1. User-Activated
2. Robot Self-Activated
3. Other
4. not mentioned

14.2 Tasks

14.2.1 General/Not Specified
1. Mentioned
2. Not Mentioned

14.2.2 Aiding/Assisting Tasks (ie reaching, lifting)
1. Mentioned
2. Not Mentioned

14.2.3 Cleaning/Organizing/Chore-Type Tasks
1. Mentioned
2. Not Mentioned

14.2.4 Cooking Tasks
1. Mentioned
2. Not Mentioned

14.2.5 Housework/Repairs/Home Maintenance
1. Mentioned
2. Not Mentioned

14.2.6 Providing Company/Conversation
1. Mentioned
2. Not Mentioned

14.2.7 Security Tasks
1. Mentioned
2. Not Mentioned

14.2.8 Serving Tasks
1. Mentioned
2. Not Mentioned

14.2.9 Taking care of/feeding pets
1. Mentioned
2. Not Mentioned

14.2.10 Working with other machines/devices
1. Mentioned
2. Not Mentioned

14.2.11 Other
1. Mentioned
2. Not Mentioned

14.3 Control

14.3.1 Programmed
1. General
2. Pre-programmed (not by user)/automatic
3. User-Programmed

4. Both pre-and user-programmed
5. Not Mentioned

14.3.2 Direct Human Control
1. Mentioned
2. Not Mentioned

14.4 Location of Person
1. Outside Home
2. In Home, general
3. In home, doing own activities
4. In same location as robot, monitoring/watching
5. In home and away from home (eg school/work and home after)
6. Other
7. Not Mentioned

14.5 Robot Activity When User is Away from Home
1. Robot Active
2. Robot turned off
3. Robot active and/or off (active then turns self off)
4. Other
5. Not Mentioned

14.6 Duration of Robot Activity
1. Continuously Active (performs tasks all day)
2. All day but not at night
3. All night but not day
4. Robot not Active/off for some part of the day
5. Other
6. Not Mentioned

15. Robot Access

15.1 Where Robot is Allowed in the Home
1. Everywhere/all rooms
2. Only in certain rooms/locations, general
3. Only in Rooms where doing tasks/assigned to be
4. Other
5. Not Mentioned

15.2 Where Robot is NOT Allowed in the Home

15.2.1 Certain Rooms/Locations/General
1. Mentioned
2. Not Mentioned

15.2.2 Certain Rooms/Locations when it doesnt have reason
1. Mentioned
2. Not Mentioned

15.2.3 Near Certain People (e.g., children)
1. Mentioned
2. Not Mentioned

15.2.4 Near Certain Objects/Places Where it Could Cause Harm
1. Mentioned
2. Not Mentioned

15.2.5 Places when User is in those Places (ie bathroom)
1. Mentioned
2. Not Mentioned

15.2.6 No Restrictions
1. Mentioned
2. Not Mentioned

15.2.7 Other
1. Mentioned
2. Not Mentioned

16. Frequency of Interaction

16.1 Frequency of Interaction
1. As often as possible/continuously
2. At least once a day but not continuously (ie "everyday")
3. At least once a week but less than once a day
4. Less than once a week
5. Only when needed/instructed
6. As infrequently as possible
7. Schedule depends on specific tasks
8. Other

17. Other Users of Robot
17.1 Other Users
1. Family, general
2. Family, in household
3. Family outside of household
4. Others in household (not family)
5. Visitors/guests
6. No one else
7. Other

17.2 Use of Robot By Others
1. Same Way
2. Different Types of Tasks
3. Different Number of Tasks
4. Different type of interaction/attitude
5. Don't Know
6. Other
7. Not Mentioned

18. Robot Activity when Guests Present
18.1 Interaction with Guests
18.1.1 Continues tasks
1. General
2. Tasks, in presence of guests
3. Tasks, out of way or view of guests
4. Not mentioned

18.1.2 Assists in background (ie cooking/cleaning)
1. Mentioned
2. Not Mentioned

18.1.3 Serves Guests (ie brings food and/or drinks)
1. Mentioned
2. Not Mentioned

18.1.4 Interacts with Guests (tells jokes, entertains guests)
1. Mentioned
2. Not Mentioned

18.1.5 Robot is Shown off/Novelty Item
1. Mentioned
2. Not Mentioned

18.1.6 Robot Off/In Storage
1. Mentioned
2. Not Mentioned

18.1.7 Other
1. Mentioned
2. Not Mentioned

19. Robot Activity when Users Away from home
19.1 User Away for a few Hours
19.1.1 Nothing/In Storage/Charging/Off
1. General
2. Off if done with tasks/not scheduled to do anything

3. Other
4. Not Mentioned

19.1.2 Continue Scheduled Tasks
1. General
2. At reduced frequency
3. Only if needed
4. Other
5. Not Mentioned

19.1.3 New Tasks (ie home security)
1. Mentioned
2. Not Mentioned

19.1.4 Robot Lent Out/Someone Else Borrows
1. Mentioned
2. Not Mentioned

19.1.5 Other
1. Mentioned
2. Not Mentioned

19.2 User Away for a Week

19.2.1 Nothing/Off/In Storage/Charging
1. General
2. If done with tasks/not scheduled to do anything
3. Other
4. Not Mentioned

19.2.2 Continuing Scheduled Tasks
1. General
2. At reduced frequency
3. Only as needed
4. Other
5. Not Mentioned

19.2.3 New Tasks (eg Home Security)
1. Mentioned
2. Not Mentioned

19.2.4 Robot Lent Out/Someone Else Borrows
1. Mentioned
2. Not Mentioned

19.2.5 Other
1. Mentioned
2. Not Mentioned

20. Robot Malfunction

20.1 Robot Makes Mistake

20.1.1 Try to Fix by Self/Reprogram
1. General
2. Initially (i.e., try to fix by self first)
3. Not mentioned

20.1.2 Call Repair Company/Manufacturer/Get Repaired by Someon
1. Mentioned
2. Not mentioned

20.1.3 Try to Teach Robot/ Notify Robot of Mistake
1. Mentioned
2. Not mentioned

20.1.4 Get New Robot/Get Rid of Old Robot
1. Mentioned
2. Not mentioned

20.1.5 Don’t know
1. Mentioned
2. Not mentioned

20.1.6 Other
1. Mentioned
2. Not mentioned
20.2 Robot Breaks Down or Stops Working
20.2.1 Try to Fix by Self/Reprogram
1. General
2. Initially (i.e., try to fix by self first)
3. Not mentioned
20.2.2 Call Repair Company/Manufacturer/Get Repaired by Someon
1. Mentioned
2. Not mentioned
20.2.3 Try to Teach Robot/ Notify Robot of Mistake
1. Mentioned
2. Not mentioned
20.2.4 Get New Robot/Get Rid of Old Robot
1. Mentioned
2. Not mentioned
20.2.5 Don't know
1. Mentioned
2. Not mentioned
20.2.6 Other
1. Mentioned
2. Not mentioned
21. Robot for Entertainment: Tasks
21.1.1 Direct Entertainment
1. General
2. One-sided
3. Two-sided/interaction between robot and user
4. Both one- and two-sided
5. Other
6. Not mentioned
21.1.2 Indirect Entertainment
1. Works/manipulates existing devices
2. Replaces existing devices
3. Both works with existing devices and replaces existing devic
4. Other
5. Not mentioned
21.1.3 Entertaining Guests (e.g., serving food and drinks
1. Mentioned
2. Not mentioned
21.1.4 Don't know
1. Mentioned
2. Not mentioned
21.1.5 Other
1. Mentioned
2. Not mentioned
22. Robot for Entertainment: Appearance
22.1 Comparison to Original Robot Appearance
1. Robot has same appearance as previously described robot
2. Robot has different appearance than previously described rob
3. Robot more human-like than previously described robot
4. Robot less human-like/more machine-like than previously desc
5. Other
6. Not mentioned
22.2. Overall Appearance
1. Human-like appearance (ie Very human-like)

2. Characteristics of both a human and a machine/appliance
3. Machine-like/Mechanical (ie any shape that isn't human)
4. Looks like existing machine/appliance
5. Looks like robot/character from fictional movie
6. Looks like an animal
7. Other
8. Not mentioned

23. Robot for Entertainment: Control
    23.1 Control, General
        23.1.1 Programmed
            1. General
            2. Pre-programmed (not by user)/automatic
            3. User-programmed
            4. Both pre- and user-programmed
            5. Not Mentioned
        23.1.2 Direct Human Control
            1. Mentioned
            2. Not Mentioned
        23.1.3 Don't Know
            1. Mentioned
            2. Not Mentioned
        23.1.4 Other
            1. Mentioned
            2. Not mentioned
    23.2 User-Directed Control, Specific
        23.2.1 Input/Interface on Robot (touch screen, buttons)
            1. Mentioned
            2. Not Mentioned
        23.2.2 Remote Control/Game Controller
            1. Mentioned
            2. Not Mentioned
        23.2.3 Teaching/Training/Robot Learns (it is shown what to do)
            1. Mentioned
            2. Not Mentioned
        23.2.4 Voice Activation/Commands
            1. Mentioned
            2. Not Mentioned
        23.2.5 Other
            1. Mentioned
            2. Not Mentioned
    23.3 Sensors
        1. Mentioned
        2. Not Mentioned

24. Robot for Entertainment: Overall Opinion
    24.1 Overall Opinion
        24.1.1 Overall Attitude
            1. Positive
            2. Positive and negative
            3. Negative/don’t see a lot of benefit
            4. Don’t know/no opinion
            5. Other
            6. Not mentioned
        24.1.2 Benefit
            1. Benefit, general
            2. Benefit to self
            3. Benefit to others

4. Benefit to self under certain circumstances/ in future
5. Not as much benefit as other type of robot
6. More of novelty/luxury-type item
7. Not a lot/no benefit
8. Other
9. Not mentioned

24.1.3 Feasibility

1. Robot feasible
2. Robot not feasible
3. Don't know
4. Other
5. Not mentioned

25. Robot for Health-Related Activities: Tasks

25.1 Tasks

25.1.1 Cleaning Activities

1. Mentioned
2. Not mentioned

25.1.2 General Care

1. Mentioned
2. Not mentioned

25.1.3 Health Monitoring/Diagnosis

1. Mentioned
2. Not mentioned

25.1.4 Medication Administration

1. Mentioned
2. Not mentioned

25.1.5 Medication Reminder

1. Mentioned
2. Not mentioned

25.1.6 Mobility Assistance

1. Mentioned
2. Not mentioned

25.1.7 Promotion of Health Activities, Diet

1. Mentioned
2. Not mentioned

25.1.8 Promotion of Health Activities, Exercise

1. Mentioned
2. Not mentioned

25.1.9 Promotion of Health Activities, Hygiene

1. Mentioned
2. Not mentioned

25.1.10 Don't Know

1. Mentioned
2. Not mentioned

25.1.11 Other

1. Mentioned
2. Not mentioned

26. Robot for Health-Related Activities: Appearance

26.1 Comparison to Original Robot Appearance

1. Robot has same appearance as previously described robot
2. Robot has different appearance than previously described rob
3. Robot more human-like than previously described robot
4. Robot less human-like/more machine-like than previously desc
5. Other
6. Not mentioned

26.2. Overall Appearance

1. Human-like appearance (ie Very human-like)
2. Characteristics of both a human and a machine/appliance
3. Machine-like/Mechanical (ie any shape that isn't human)
4. Looks like existing machine/appliance
5. Looks like robot/character from fictional movie
6. Looks like an animal
7. Other
8. Not mentioned

27. Robot for Health-Related Activities: Control
    27.1 Control, General
        27.1.1 Programmed
            1. General
            2. Pre-programmed (not by user)/automatic
            3. User-programmed
            4. Both pre- and user-programmed
            5. Not Mentioned
        27.1.2 Direct Human Control
            1. Mentioned
            2. Not Mentioned
        27.1.3 Don't know
            1. Mentioned
            2. Not Mentioned
        27.1.4 Other
            1. Mentioned
            2. Not mentioned
    27.2 User-Directed Control, Specific
        27.2.1 Input/Interface on Robot (touch screen, buttons)
            1. Mentioned
            2. Not Mentioned
        27.2.2 Remote Control/ Game Controller
            1. Mentioned
            2. Not Mentioned
        27.2.3 Teaching/Training/Robot Learns (it is shown what to do)
            1. Mentioned
            2. Not Mentioned
        27.2.4 Voice Activation/Commands
            1. Mentioned
            2. Not Mentioned
        27.2.5 Other
            1. Mentioned
            2. Not Mentioned
    27.3 Sensors
        1. Mentioned
        2. Not Mentioned

28. Robot for Health-Related Activities: Overall Opinion
    28.1 Overall Opinion
    28.1.1 Overall Attitude
        1. Positive
        2. Positive and negative
        3. Negative/don't see a lot of benefit
        4. Don't know/no opinion
        5. Other
        6. Not mentioned
    28.1.2 Benefit
        1. Benefit, general
        2. Benefit to self

3. Benefit to others
4. Benefit to self under certain circumstances/ in future
5. Not as much benefit as other type of robot
6. More of novelty/luxury-type item
7. Not a lot/no benefit
8. Other
9. Not mentioned

28.1.3 Feasibility
1. Robot feasible
2. Robot not feasible
3. Don’t know
4. Other
5. Not mentioned

29. Robot for Security: Tasks
29.1 Tasks
29.1.1 Emergency Notification
1. Mentioned
2. Not mentioned

29.1.2 Monitoring Home
1. Mentioned
2. Not mentioned

29.1.3 Security System, Monitoring for Intruders/Unusual Activ
1. Mentioned
2. Not mentioned

29.1.4 Security System, Actively Defending Against Intruders
1. Mentioned
2. Not mentioned

29.1.5 Don’t Know
1. Mentioned
2. Not mentioned

29.1.6 Other
1. Mentioned
2. Not mentioned

30. Robot for Security: Appearance
30.1 Comparison to Original Robot Appearance
1. Robot has same appearance as previously described robot
2. Robot has different appearance than previously described rob
3. Robot more human-like than previously described robot
4. Robot less human-like/more machine-like than previously desc
5. Other
6. Not mentioned

30.2 Overall Appearance
1. Human-like appearance (ie Very human-like)
2. Characteristics of both a human and a machine/appliance
3. Machine-like/Mechanical (ie any shape that isn't human)
4. Looks like existing machine/appliance
5. Looks like robot/character from fictional movie
6. Looks like an animal
7. Other
8. Not mentioned

31. Robot for Security: Control
31.1 Control, General
31.1.1 Programmed
1. General
2. Pre-programmed (not by user)/automatic
3. User-programmed

4. Both pre- and user-programmed
5. Not Mentioned
31.1.2 Direct Human Control
1. Mentioned
2. Not Mentioned
31.1.3 Don't know
1. Mentioned
2. Not Mentioned
31.1.4 Other
1. Mentioned
2. Not mentioned
31.2 User-Directed Control, Specific
31.2.1 Input/Interface on Robot (touch screen, buttons)
1. Mentioned
2. Not Mentioned
31.2.2 Remote Control/ Game Controller
1. Mentioned
2. Not Mentioned
31.2.3 Teaching/Training/Robot Learns (it is shown what to do)
1. Mentioned
2. Not Mentioned
31.2.4 Voice Activation/Commands
1. Mentioned
2. Not Mentioned
31.2.5 Other
1. Mentioned
2. Not Mentioned
31.3 Sensors
1. Mentioned
2. Not Mentioned
32. Robot for Security: Overall Opinion
33.1.1 Overall Attitude
1. Positive
2. Positive and negative
3. Negative/don't see a lot of benefit
4. Don't know/no opinion
5. Other
6. Not mentioned
33.1.2 Benefit
1. Benefit, general
2. Benefit to self
3. Benefit to others
4. Benefit to self under certain circumstances/ in future
5. Not as much benefit as other type of robot
6. More of novelty/luxury-type item
7. Not a lot/no benefit
8. Other
9. Not mentioned
32.1.3 Feasibility
1. Robot feasible
2. Robot not feasible
3. Don't know
4. Other
5. Not mentioned
33. Negative Characteristics of Robots
33.1 Unwanted Robot Characteristics

33.1.1 Aggressive/Turns Against User
1. Mentioned
2. Not mentioned

33.1.2 Disruptive/Intrusive/Annoying/Noisy
1. Mentioned
2. Not mentioned

33.1.3 Damaging to Home
1. Mentioned
2. Not mentioned

33.1.4 Difficult to Maintain/Easy to Break/Malfunctions
1. Mentioned
2. Not mentioned

33.1.5 Difficult to use
1. Mentioned
2. Not mentioned

33.1.6 Expensive
1. Mentioned
2. Not mentioned

33.1.7 Human-Like Appearance
1. Mentioned
2. Not mentioned

33.1.8 Reasoning Ability/Ability to Think on its Own/Questions
1. Mentioned
2. Not mentioned

33.1.9 Uncontrollable/Chaotic/Won't Follow Commands
1. Mentioned
2. Not mentioned

33.1.10 Don't know/Can't Think of Any
1. Mentioned
2. Not mentioned

33.1.11 Other
1. Mentioned
2. Not mentioned

34. Considerations before getting a robot

34.1 Considerations before Getting a Robot

34.1.1 Capabilities of Robot/What it can Do/Usefulness
1. Mentioned
2. Not mentioned

34.1.2 Control/How Robot is Instructed to Do Things/Ease of Us
1. Mentioned
2. Not mentioned

34.1.3 Cost of Robot
1. Mentioned
2. Not mentioned

34.1.4 Limitations of Robot/What it Can't Do
1. Mentioned
2. Not mentioned

34.1.5 Maintenance Information
1. Mentioned
2. Not mentioned

34.1.6 Opinions of Others who have Robot
1. Mentioned
2. Not mentioned

34.1.7 Reliability of Robot/Robot has been Tested
1. Mentioned
2. Not mentioned

34.1.8 Safety of Robot/Knowledge that Robot Will Not do Harm
1. Mentioned
2. Not mentioned
34.1.9 Don't Know
1. Mentioned
2. Not mentioned
34.1.10 Other
1. Mentioned
2. Not mentioned
35. Lifestyle Changes
35.1 Lifestyle Changes
35.1.1 No changes
1. General
2. No changes, would not want robot if had to change lifestyle
3. Other
4. Not mentioned
35.1.2 Positive Changes to Lifestyle
1. Mentioned
2. Not mentioned
35.1.3 Neutral/General Changes to Lifestyle
1. Mentioned
2. Not mentioned
35.1.4 Negative Changes to Lifestyle
1. Mentioned
2. Not mentioned
35.1.5 Don't Know
1. Mentioned
2. Not mentioned
35.1.6 Other
1. Mentioned
2. Not mentioned
36. Changes in Views/Opinions about Robots
36.1 Changes in Views/Opinions about Robots
36.1.1 Views/Opinions Stayed Exactly the Same
1. Mentioned
2. Not mentioned
36.1.2 Change in Number of Tasks/Types of Things Robot Can Do
1. More tasks/new type of tasks
2. Fewer tasks/more limited
3. Other
4. Not mentioned
36.1.3 Change in Appearance/What a Robot may Look Like
1. Mentioned
2. Not mentioned
36.1.4 Change in Feasibility/Reality of Robots
1. Mentioned
2. Not mentioned
36.1.5 Change in Attitude about Robots
1. Mentioned
2. Not mentioned
36.1.6 Never thought About Robots Before/To This Extent
1. Mentioned
2. Not mentioned
36.1.7 Don't Know
1. Mentioned
2. Not mentioned

36.1.8 Other

1. Mentioned
2. Not mentioned

APPENDIX T: INTERVIEW CODING DATA

Data from Interview Coding

Coding Dimension	Younger Adults (*N* = 12)	Younger-Older Adults (*N* = 12)	Older-Older Adults (*N* = 12)	Combined (*N* = 36)
	N			
1. Robot Definition				
1.1 Mechanical/Electronic				
1. Device or machine	4	4	1	9
2. Electronic device or	1	1	1	3
3. Mechanical device or	5	6	5	16
4. Electronic and	1	0	2	3
5. Not mentioned	1	1	3	5
1.2 Human Likeness				
1. Acts/functions like a	2	0	2	4
2. Looks and acts like a	0	0	0	0
3. Not a human	0	0	1	1
4. Like a human in some	1	0	0	1
5. Other	0	2	0	2
6. Not mentioned	9	10	9	28
1.3 Function				
1. Does tasks/functions,	0	2	2	4
2. Replaces human	4	4	3	11
3. Augments/assists	1	0	1	2
4. Does whatever human	5	2	0	7
5. Other	0	1	1	2
6. Not mentioned	2	3	5	10
1.4 Control				
1.4.1 Programmed				
1. General	1	2	0	3
2. Pre-programmed	1	1	3	5
3. User-programmed	0	0	0	0
4. Both pre- and	0	0	0	0
5. Not mentioned	10	9	9	28
1.4.2 Direct Human				
1. Mentioned	1	0	1	2
2. Not mentioned	11	12	11	34

Data from Interview Coding (cont')

	N			
Coding Dimension	**Younger Adults**	**Younger-Older Adults**	**Older-Older Adults**	**Combined**
2. Source of Definition				
2.1 TV				
1. General	1	1	2	4
2. Fiction/sci-fi shows	1	1	0	2
3. Non-fiction/scientific	0	1	1	2
4. Advertisements	0	1	0	1
5. Other	0	0	1	1
6. Not mentioned	10	8	8	26
2.2 Movies				
1. General	2	1	1	4
2. Fiction/sci-fi movies	4	3	1	8
3. Other	0	0	0	0
4. Not mentioned	6	8	10	24
2.3 Print media/Books				
1. General	1	1	2	4
2. Fictional/sci-fi books	1	0	1	2
3. Non-fiction/scientific	1	0	0	1
4. Other	0	1	0	1
5. Not mentioned	9	10	9	28
2.4 Experience				
2.4.1 General experience				
1. First-hand	3	5	3	11
2. Second-hand	1	0	2	3
3. First- and	0	0	1	1
4. Other	0	0	0	0
5. Not	8	7	6	21
2.4.2 Consumer Robot				
1. Mentioned	1	1	3	5
2. Not	11	11	9	31
2.4.3 Factory/Processing				
1. Mentioned	1	4	1	6
2. Not	11	8	11	30
2.4.4 Medical Setting				
1. Mentioned	1	0	0	1
2. Not	11	12	12	35
2.5 Thinking/Imagining				
1. General	2	0	1	3
2. Thinking/imagining	2	3	1	6
3. Thinking/imagining	1	1	0	2
4. Other	0	0	0	0
5. Not mentioned	7	8	10	25

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
3. Robot-Technology Differences				
3.1 Difference between Robots				
1. Differences between	10	8	7	25
2. No differences between	0	1	3	4
3. Don't know	1	2	1	4
4. Other/unclear answer	1	1	1	3
3.2 More Human-Like than				
1. Mentioned	2	1	0	3
2. Not mentioned	10	11	12	33
3.3 Different Types of Tasks				
3.3.1 More "human" tasks				
1. Mentioned	4	1	1	6
2. Not mentioned	8	11	11	30
3.3.2 More Tasks				
1. Mentioned	0	2	0	2
2. Not mentioned	12	10	12	34
3.3.3 More Complicated				
1. Mentioned	0	2	0	2
2. Not mentioned	12	10	12	34
3.3.4 More Personalized				
1. Mentioned	0	1	2	3
2. Not mentioned	12	11	10	33
3.3.5 Other Task				
1. Mentioned	1	3	0	4
2. Not mentioned	11	9	12	32
3.4 Different Control Than				
3.4.1 Programmed				
1. More programmed,	2	4	1	7
2. More pre-	2	1	1	4
3. More user-	1	0	1	2
4. Less	0	0	0	0
5. Not mentioned	7	7	9	23
3.4.2 More Direct Human				
1. More direct control	1	0	0	1
2. Less direct control	1	0	0	1
3. Not mentioned	10	12	12	34
3.5 Other Differences				
3.5.1 More				
1. Mentioned	3	2	0	5
2. Not mentioned	9	10	12	31
3.5.2 More				
1. Mentioned	2	1	2	5
2. Not mentioned	10	11	10	31
3.5.3 Other				
1. Mentioned	0	2	1	3
2. Not mentioned	12	10	11	33

Data from Interview Coding (cont')

	N			
Coding Dimension	**Younger Adults**	**Younger-Older Adults**	**Older-Older Adults**	**Combined**
4. Robot Tasks				
4.1 Robot Tasks				
4.1.1 Aiding/Assisting tasks				
1. Mentioned	0	3	4	7
2. Not mentioned	12	9	8	29
4.1.2				
1. Mentioned	12	12	11	35
2. Not mentioned	0	0	1	1
4.1.3 Cooking Tasks				
1. Mentioned	3	2	1	6
2. Not mentioned	9	10	11	30
4.1.4 House Repair/Home				
1. Mentioned	1	5	1	7
2. Not mentioned	11	7	11	29
4.1.5 Providing				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36
4.1.6 Security Tasks				
1. Mentioned	0	1	1	2
2. Not mentioned	12	11	11	34
4.1.7 Serving Tasks				
1. Mentioned	1	1	0	2
2. Not mentioned	11	11	12	34
4.1.8 Taking care of/feeding				
1. Mentioned	1	0	1	2
2. Not mentioned	11	12	11	34
4.1.9 Working with other				
1. Mentioned	0	0	3	3
2. Not mentioned	12	12	9	33
4.1.10 Other				
1. Mentioned	1	1	2	4
2. Not mentioned	11	11	10	32
5. Why those tasks?				
5.1 Reasons for Tasks				
5.1.1 Difficulty doing tasks				
1. Currently difficult	0	6	0	6
2. May be difficult in	0	0	2	2
3. Not mentioned	12	6	10	28
5.1.2 Disinterest in				
1. Mentioned	11	8	7	26
2. Not mentioned	1	4	5	10
5.1.3 Tasks Not Currently				
1. Mentioned	2	1	0	3
2. Not mentioned	10	11	12	33
5.1.4 Other				
1. Mentioned	0	0	4	4
2. Not mentioned	12	12	8	32

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
6. Task Frequency				
6.1 Task Frequency				
1. As often as	1	0	0	1
2. At least once a day but	6	3	6	15
3. At least once a week	0	4	2	6
4. Less than once a week	0	0	0	0
5. Only when needed or	2	1	1	4
6. Both scheduled and on	1	0	0	1
7. Schedule depends on	2	4	1	7
8. Other	0	0	2	2
7. Robot does tasks with or				
7.1 With/Without User				
1. With user	0	4	3	7
2. Without user	6	4	5	15
3. Sometimes with and	2	3	2	7
4. Initially with, then	3	1	0	4
5. No preference	1	0	1	1
6. Other	0	0	1	1
7.2 Why With?				
1. Have to monitor/don't	2	4	1	7
2. Have to be present to	2	4	2	8
3. Other	1	0	2	3
4. Not mentioned	7	4	7	18
7.3 Why Without?				
1. Trust/Don't have to	2	1	2	5
2. Save time/want to do	6	4	1	11
3. Don't want interference	0	1	1	2
4. Other	1	1	2	4
5. Not mentioned	3	5	6	14
8. Location of person				
8.1 Location of Person when				
1. Outside home	3	3	2	8
2. In home, general	0	1	1	2
3. In home, doing own	4	2	3	9
4. Same location as robot,	0	4	3	7
5. In home or away from	4	1	3	8
6. Initially in home, then	1	1	0	2
7. Other	0	0	0	0

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
9. Robot Control				
9.1 Control, General				
9.1.1 Programmed				
1. General	2	3	5	10
2. Pre-programmed	2	2	1	5
3. User-programmed	6	2	1	9
4. Both pre- and	0	1	1	2
5. Not mentioned	2	4	4	10
9.1.2 Direct Human				
1. Mentioned	6	5	4	15
2. Not mentioned	6	7	8	21
9.1.3 Don't Know				
1. Mentioned	0	0	1	1
2. Not mentioned	12	12	11	35
9.1.4 Other				
1. Mentioned	1	2	0	3
2. Not mentioned	11	10	12	33
9.2 User-Directed Control,				
9.2.1 General/Ambiguous				
1. Mentioned	2	1	1	4
2. Not mentioned	10	11	11	32
9.2.2 Input/Interface on				
1. Mentioned	2	1	1	4
2. Not mentioned	10	11	11	32
9.2.3 Remote				
1. Mentioned	1	0	0	1
2. Not mentioned	11	12	12	35
9.2.4				
1. Mentioned	1	1	0	2
2. Not mentioned	11	11	12	34
9.2.5 Voice				
1. Mentioned	1	6	2	9
2. Not mentioned	11	6	10	27
9.2.6 Other				
1. Mentioned	0	1	3	4
2. Not mentioned	12	11	9	32
9.3 Sensors				
1. Mentioned	1	1	0	2
2. Not mentioned	11	11	12	32

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
10. Task Approval				
10.1 Tasks Without Approval				
1. No, general	6	6	4	17
2. No, robots must only	2	2	1	5
3. No, other	1	1	1	3
4. Yes, general	0	1	2	3
5. Yes, but only certain	2	0	1	3
6. Yes, but only for	1	1	0	2
7. Yes, other	0	0	0	0
8. Don't know	0	0	3	3
9. Other	0	0	0	0
11. Robot Activity when Tasks				
11.1 Robot Activity When				
11.1.1 Shuts off/Turns off				
1. General	1	0	0	1
2. Automatically	2	1	5	8
3. User-	2	1	1	4
4. Either	1	1	0	2
5. Not	6	9	5	20
11.1.2 Stands				
1. Mentioned	1	0	1	2
2. Not	11	12	10	33
11.1.3 Goes to Specific				
1. Mentioned	4	7	5	16
2. Not	8	5	6	19
11.1.4 Gets Recharged				
1. Mentioned	2	1	0	3
2. Not	10	11	11	32
11.1.5 Other				
1. Mentioned	1	4	1	6
2. Not	11	8	10	29
12. Robot Appearance				
12.1 Overall Appearance				
1. Human-like	4	4	1	9
2. Human- and a	2	2	1	5
3. Machine-	2	3	4	9
4. Looks like existing	0	1	3	4
5. Looks like	1	0	2	3
6. Looks like an animal	0	0	0	0
7. Other	1	0	1	2
8. Not mentioned	2	2	0	4

[1] missing data from one older-older adult; (n = 35)

Data from Interview Coding (cont')

Coding Dimension	N Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
12.2 Height				
1. Much shorter than	0	2	3	5
2. Slightly shorter than a	2	2	2	6
3. Same height as human	5	2	2	9
4. Taller than a human	1	0	0	1
5. Height changes or	2	1	1	4
6. Other	1	2	1	4
7. Not mentioned	1	3	3	7
12.3 Head and Facial Features				
12.3.1 Head				
1. General	1	1	1	3
2. Human-like	2	0	0	2
3. Machine-like	0	0	0	0
4. No head	0	0	0	0
5. Other	0	1	0	1
6. Not mentioned	9	10	11	30
12.3.2 Face				
1. General	0	1	0	1
2. Human-like	1	0	0	1
3. Machine-like	0	0	0	0
4. No face	3	0	0	3
5. Other	0	0	0	0
6. Not mentioned	8	11	12	31
12.3.3 Eyes				
1. General	1	0	0	1
2. Human-like	1	1	0	2
3. Machine-like	0	1	0	1
4. No eyes	0	0	0	0
5. Other	0	0	0	0
6. Not mentioned	10	10	12	32
12.3.4 Mouth				
1. General	1	0	0	1
2. Human-like	1	0	0	1
3. Machine-like	0	1	0	1
4. No mouth	0	0	0	0
5. Other	0	0	0	0
6. Not mentioned	10	11	12	33
12.3.5 Nose				
1. General	0	0	0	0
2. Human-like	1	0	0	1
3. Machine-like	0	0	0	0
4. No nose	0	1	0	1
5. Other	0	0	0	0
6. Not mentioned	11	11	12	34

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
12.4 Arms and Hands				
12.4.1. Arms				
1. General	5	3	1	9
2. Human-like	2	0	1	3
3. Machine-like	1	2	1	4
4. No arms	0	0	0	0
5. Other	0	1	0	1
6. Not mentioned	4	6	9	19
12.4.2 Hands/Fingers				
1. General	0	2	0	2
2. Human-like	1	0	0	1
3. Machine-like	0	0	0	0
4. No Hands	0	0	0	0
5. Other	0	0	0	0
6. Not mentioned	11	10	12	33
12.5 Mobility				
1. Moves around, general	0	2	3	5
2. Has legs, walks like	2	1	1	4
3. Has	5	3	4	12
4. Has legs and/or	4	1	0	5
5. Moves, other	0	1	0	1
6. Stays in one place	0	0	1	1
7. Other	0	0	2	2
8. Not mentioned	1	4	1	6
12.6 Material				
12.6.1 Metal				
1. Mentioned	11	11	7	29
2. Not mentioned	1	1	5	7
12.6.2 Plastic				
1. Mentioned	5	7	5	17
2. Not mentioned	7	5	7	19
12.6.3 Cloth/Cushioning				
1. Mentioned	0	1	0	1
2. Not mentioned	12	11	12	35
12.6.4 Other Material				
1. Mentioned	2	2	4	8
2. Not mentioned	10	10	8	28
12.7 Gender				
1. Feminine	1	0	0	1
2. Masculine	1	0	0	1
3. Neither feminine or	1	0	0	1
4. Not mentioned	9	12	12	33
12.8 Interface				
1. Mentioned	2	1	2	5
2. Not mentioned	10	11	10	31

Data from Interview Coding (cont')

Coding Dimension	N Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
13. Reasons for Appearance				
13.1 Reasons for Appearance				
13.1.1 Robots Depicted				
1. Mentioned	3	1	4	8
2. Not mentioned	9	11	8	28
13.1.2 Matches				
1. Mentioned	5	4	2	11
2. Not mentioned	7	8	10	25
13.1.3 More Friendly				
1. Mentioned	3	2	0	5
2. Not mentioned	9	10	12	31
13.1.4 Previous				
1. Mentioned	2	1	2	5
2. Not mentioned	10	11	10	31
13.1.5 Imagination				
1. Mentioned	2	4	5	11
2. Not mentioned	10	8	7	25
13.1.6 Don't Want				
1. Mentioned	1	0	0	1
2. Not mentioned	11	12	12	35
13.1.7 Don't Know				
1. Mentioned	0	0	1	1
2. Not mentioned	12	12	11	35
13.1.8 Other				
1. Mentioned	1	2	2	5
2. Not mentioned	11	10	10	31

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
14. Typical Day with Robot				
14.1 Activation				
1. User-activated	6	0	2	8
2. Robot self-activated	0	3	2	5
3. Other	0	0	0	0
4. Not mentioned	6	9	8	23
14.2 Tasks				
14.2.1 General/Not				
1. Mentioned	4	2	1	7
2. Not mentioned	8	10	11	29
14.2.2 Aiding/Assisting				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36
14.2.3				
1. Mentioned	8	9	10	27
2. Not mentioned	4	3	2	9
14.2.4 Cooking Tasks				
1. Mentioned	1	2	1	4
2. Not mentioned	11	10	11	32
14.2.5 Home Repair/Home				
1. Mentioned	0	2	0	2
2. Not mentioned	12	10	12	34
14.2.6 Providing				
1. Mentioned	1	1	1	3
2. Not mentioned	11	11	11	33
14.2.7 Security Tasks				
1. Mentioned	1	1	1	3
2. Not mentioned	11	11	11	33
14.2.8 Serving Tasks				
1. Mentioned	1	2	2	5
2. Not mentioned	11	10	10	31
14.2.9 Taking Care of Pets				
1. Mentioned	0	1	0	1
2. Not mentioned	12	11	12	35
14.2.10 Working with Other				
1. Mentioned	0	2	2	4
2. Not mentioned	12	10	10	32
14.2.11 Other				
1. Mentioned	1	2	2	5
2. Not mentioned	11	10	10	31

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
14.3 Control				
14.3.1 Programmed				
1. General	2	3	1	6
2. Pre-	0	0	0	0
3. User-programmed	2	1	0	3
4. Both pre-and user-	0	0	1	1
5. Not mentioned	8	8	10	26
14.3.2 Direct Human				
1. Mentioned	1	2	1	4
2. Not mentioned	11	10	11	32
14.4 Location of Person				
1. Outside home	3	1	0	4
2. In home, general	0	1	1	2
3. In home, doing own	1	0	0	1
4. In same location as	0	1	0	1
5. In home and away from	6	1	0	7
6. Other	1	0	0	1
7. Not mentioned	1	8	11	20
14.5 Robot Activity When User				
1. Robot active	7	1	1	9
2. Robot turned off	1	0	0	1
3. Robot active and/or off	0	0	0	0
4. Other	0	0	0	0
5. Not mentioned	4	11	11	26
14.6 Duration of Robot Activity				
1. Continuously active	1	3	2	6
2. All day but not at night	6	3	2	11
3. All night but not day	0	0	0	0
4. Robot not active/off for	1	2	2	5
5. Other	1	1	1	3
6. Not mentioned	3	3	5	11
15. Robot Access				
15.1 Where Robot is Allowed				
1. Everywhere/all rooms	6	8	7	21
2. Only in certain	2	0	0	2
3. Only in rooms where	2	4	4	10
4. Other	2	0	1	3
5. Not mentioned	0	0	0	0

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
15.2 Where Robot is NOT				
15.2.1 Certain				
1. Mentioned	1	1	2	4
2. Not mentioned	11	11	10	32
15.2.2 Where it Doesn't				
1. Mentioned	1	2	2	5
2. Not mentioned	11	10	10	31
15.2.3 Near Certain				
1. Mentioned	2	1	0	3
2. Not mentioned	10	11	12	33
15.2.4 Near Certain				
1. Mentioned	1	1	0	2
2. Not mentioned	11	11	12	34
15.2.5 Places when User				
1. Mentioned	2	1	0	3
2. Not mentioned	10	11	12	33
15.2.6 No Restrictions				
1. Mentioned	5	7	6	18
2. Not mentioned	7	5	6	18
15.2.7 Other				
1. Mentioned	3	0	2	5
2. Not mentioned	9	12	10	7
16. Frequency of Interaction				
16.1 Frequency of Interaction				
1. As often as	1	0	0	1
2. At least once a day but	3	4	7	14
3. At least once a week	1	0	1	2
4. Less than once a week	0	1	0	1
5. Only when	4	5	3	12
6. As infrequently as	2	0	1	3
7. Schedule depends on	1	2	0	3
8. Other	0	0	0	0
17. Other Users of Robot				
17.1 Other Users				
1. Family, general	2	1	4	7
2. Family, in	4	5	4	13
3. Family outside of	0	0	0	0
4. Others in	4	0	0	4
5. Visitors/guests	0	0	1	1
6. No one else	1	5	2	8
7. Other	0	1	1	2

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
17.2 Use of Robot By Others				
1. Same way	6	4	4	14
2. Different types of tasks	3	0	1	4
3. Different number of	1	0	0	1
4. Different type of	0	0	3	3
5. Don't know	0	0	1	1
6. Other	1	2	0	3
7. Not mentioned	1	6	3	10
18. Robot Activity when Guests				
18.1 Interaction with Guests				
18.1.1 Continues Tasks				
1. General	1	0	1	2
2. Tasks, in presence	0	1	1	2
3. Tasks, out of way	0	0	0	0
4. Not mentioned	11	11	10	32
18.1.2 Assists in				
1. Mentioned	4	1	1	6
2. Not mentioned	8	11	11	30
18.1.3 Serves Guests				
1. Mentioned	6	2	0	8
2. Not mentioned	6	10	12	28
18.1.4 Interacts with				
1. Mentioned	0	1	0	1
2. Not mentioned	12	11	12	35
18.1.5 Robot is Shown				
1. Mentioned	1	2	3	6
2. Not mentioned	11	10	9	30
18.1.6 Robot Off/In				
1. Mentioned	4	7	5	16
2. Not mentioned	8	5	7	20
18.1.7 Other				
1. Mentioned	0	0	2	2
2. Not mentioned	12	12	10	34

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
19. Robot Activity when Users				
19.1 User Away for a few				
19.1.1 Nothing/In				
1. General	3	5	8	16
2. Off if done with	7	3	3	13
3. Other	0	0	0	0
4. Not mentioned	2	4	1	7
19.1.2 Continue				
1. General	7	2	2	11
2. At reduced	0	0	0	0
3. Only if needed	1	3	3	7
4. Other	0	0	0	0
5. Not mentioned	4	7	7	18
19.1.3 New Tasks				
1. Mentioned	0	2	0	2
2. Not mentioned	12	10	12	34
19.1.4 Robot Lent				
1. Mentioned	0	0	1	1
2. Not mentioned	12	12	11	35
19.1.5 Other				
1. Mentioned	0	1	0	1
2. Not mentioned	12	11	12	35
19.2 User Away for a Week				
19.2.1 Nothing/Off/In				
1. General	7	5	6	18
2. If done with	3	2	2	7
3. Other	0	1	0	1
4. Not mentioned	2	4	4	10
19.2.2 Continuing				
1. General	3	1	1	5
2. At reduced	0	2	0	2
3. Only as needed	0	2	2	4
4. Other	0	0	0	0
5. Not mentioned	9	7	9	25
19.2.3 New Tasks				
1. Mentioned	2	2	1	5
2. Not mentioned	10	9	11	30
19.2.4 Robot Lent				
1. Mentioned	2	1	1	4
2. Not mentioned	10	11	11	32
19.2.5 Other				
1. Mentioned	0	0	1	1
2. Not mentioned	12	12	11	35

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
20. Robot Malfunction				
20.1 Robot Makes Mistake				
20.1.1 Try to Fix by				
1. General	6	5	4	15
2. Initially	1	0	1	2
3. Not mentioned	5	7	7	19
20.1.2 Call Someone				
1. Mentioned	5	4	4	13
2. Not mentioned	7	8	8	23
20.1.3 Try to Teach				
1. Mentioned	4	4	1	9
2. Not mentioned	8	8	11	27
20.1.4 Get New				
1. Mentioned	2	0	0	2
2. Not mentioned	10	12	12	34
20.1.5 Don't Know				
1. Mentioned	0	1	2	3
2. Not mentioned	12	11	10	33
20.1.6 Other				
1. Mentioned	0	0	1	1
2. Not mentioned	12	12	11	35
20.2 Robot Breaks Down or				
20.2.1 Try to Fix by				
1. General	2	0	1	3
2. Initially	2	1	1	4
3. Not mentioned	8	11	10	29
20.2.2 Call Someone				
1. Mentioned	10	12	9	31
2. Not mentioned	2	0	3	5
20.2.3 Try to Teach/				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36
20.2.4 Get New				
1. Mentioned	7	0	1	8
2. Not mentioned	5	12	11	28
20.2.5 Don't Know				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36
20.2.6 Other				
1. Mentioned	0	0	2	2
2. Not mentioned	12	12	10	34

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
21. Robot for Entertainment:				
21.1 Direct Entertainment				
1. General	0	0	0	0
2. One-sided	4	5	1	10
3. Two-sided/interaction	2	2	1	5
4. Both one- and two-	3	1	3	7
5. Other	0	0	0	0
6. Not mentioned	3	4	7	14
21.2 Indirect Entertainment				
1. Works/manipulates	2	3	4	9
2. Replaces existing	2	2	2	6
3. Both works with	1	1	1	3
4. Other	1	0	0	1
5. Not mentioned	6	6	5	17
21.3 Entertaining Guests				
1. Mentioned	1	4	0	5
2. Not mentioned	11	8	12	31
21.4 Don't know				
1. Mentioned	1	0	3	4
2. Not mentioned	11	12	9	32
21.5 Other				
1. Mentioned	1	1	3	5
2. Not mentioned	11	11	9	31
22. Robot for Entertainment:				
22.1 Comparison to Original				
1. Robot has same	4	4	4	12
2. Robot has different	1	1	0	2
3. Robot more human-	2	0	0	2
4. Robot less human-like	0	0	0	0
5. Other	1	0	0	1
6. Not mentioned	4	7	8	19
22.2. Overall Appearance				
1. Human-like	4	2	1	7
2. Human-like and	0	0	0	0
3. Machine-	2	2	2	6
4. Looks like existing	0	2	3	5
5. Looks like	0	2	0	2
6. Looks like an animal	1	0	0	1
7. Other	2	2	1	5
8. Not mentioned	1	2	5	10

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
		N		
23. Robot for Entertainment:				
23.1 Control, General				
23.1.1 Programmed				
1. General	2	5	4	11
2. Pre-	1	1	0	2
3. User-programmed	2	3	4	9
4. Both pre- and user-	2	0	0	2
5. Not mentioned	5	3	4	12
23.1.2 Direct Human				
1. Mentioned	7	5	6	18
2. Not mentioned	5	7	6	18
23.1.3 Don't Know				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	12
23.1.4 Other				
1. Mentioned	3	1	0	4
2. Not mentioned	9	11	12	32
23.2 User-Directed Control,				
23.2.1 Input/Interface on				
1. Mentioned	3	1	2	6
2. Not mentioned	9	11	10	30
23.2.2 Remote				
1. Mentioned	1	0	1	2
2. Not mentioned	11	12	11	34
23.2.3				
1. Mentioned	2	2	0	4
2. Not mentioned	10	10	12	32
23.2.4 Voice				
1. Mentioned	2	1	3	6
2. Not mentioned	10	11	9	30
23.2.5 Other				
1. Mentioned	2	1	2	5
2. Not mentioned	10	11	10	31
23.3 Sensors				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	12
24. Robot for Entertainment:				
24.1 Overall Opinion				
24.1.1 Overall Attitude				
1. Positive	2	3	3	8
2. Positive and	0	1	0	1
3. Negative/don't see a	4	0	5	9
4. Don't know/no	0	1	1	2
5. Other	0	1	0	1
6. Not mentioned	6	6	3	15

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
24.1.2 Benefit				
1. Benefit, general	0	1	1	2
2. Benefit to self	0	2	3	5
3. Benefit to others	1	0	0	1
4. Benefit to self	0	0	0	0
5. Not as much	1	1	2	4
6. More of	1	2	0	3
7. Not a lot/no	3	2	4	9
8. Other	0	0	0	0
9. Not mentioned	6	4	2	12
24.1.3 Feasibility				
1. Robot feasible	0	0	1	1
2. Robot not feasible	2	0	0	2
3. Don't know	1	0	2	3
4. Other	0	1	0	1
5. Not mentioned	9	11	9	29
25. Robot for Health-Related				
25.1 Tasks				
25.1.1 Cleaning				
1. Mentioned	3	0	3	6
2. Not mentioned	9	12	9	30
25.1.2 General Care				
1. Mentioned	2	4	2	8
2. Not mentioned	10	8	10	28
25.1.3 Health				
1. Mentioned	2	5	2	9
2. Not mentioned	10	7	10	27
25.1.4 Medication				
1. Mentioned	4	3	2	9
2. Not mentioned	8	9	10	27
25.1.5 Medication				
1. Mentioned	3	5	3	11
2. Not mentioned	9	7	9	25
25.1.6 Mobility				
1. Mentioned	2	3	1	6
2. Not mentioned	10	9	11	30
25.1.7 Promotion of				
1. Mentioned	4	2	0	6
2. Not mentioned	8	10	12	30

Data from Interview Coding (cont')

Coding Dimension	N Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
25.1.8 Promotion of Health				
1. Mentioned	5	2	1	8
2. Not mentioned	7	10	11	28
25.1.9 Promotion of Health				
1. Mentioned	0	1	3	4
2. Not mentioned	12	11	9	32
25.1.10 Don't Know				
1. Mentioned	0	1	1	2
2. Not mentioned	12	11	11	34
25.1.11 Other				
1. Mentioned	7	1	3	11
2. Not mentioned	5	11	9	25
26. Robot for Health-Related				
26.1 Comparison to Original				
1. Robot has same	5	5	3	13
2. Robot has different	2	0	0	2
3. Robot more human-like	3	0	0	3
4. Robot less human-like	0	0	0	0
5. Other	0	0	0	0
6. Not mentioned	2	7	9	18
26.2. Overall Appearance				
1. Human-like appearance	4	6	1	11
2. Human-like and	3	1	0	4
3. Machine-	4	1	1	6
4. Looks like existing	1	1	4	6
5. Looks like	0	1	1	2
6. Looks like an animal	0	0	1	1
7. Other	0	1	2	3
8. Not mentioned	0	1	2	3
27. Robot for Health-Related				
27.1 Control, General				
27.1.1 Programmed				
1. General	2	8	7	17
2. Pre-	3	1	0	4
3. User-programmed	4	0	1	5
4. Both pre- and user-	0	1	0	1
5. Not mentioned	3	2	4	9
27.1.2 Direct Human				
1. Mentioned	3	4	2	9
2. Not mentioned	9	8	10	27
27.1.3 Don't know				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36
27.1.4 Other				
1. Mentioned	2	1	1	4
2. Not mentioned	10	11	11	32

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
27.2 User-Directed Control,				
27.2.1 Input/Interface on				
1. Mentioned	0	2	1	3
2. Not mentioned	12	10	11	33
27.2.2 Remote Control/				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36
27.2.3				
1. Mentioned	1	0	0	1
2. Not mentioned	11	12	12	35
27.2.4 Voice				
1. Mentioned	0	2	1	3
2. Not mentioned	12	10	11	33
27.2.5 Other				
1. Mentioned	3	1	0	4
2. Not mentioned	9	11	12	32
27.3 Sensors				
1. Mentioned	1	0	1	2
2. Not mentioned	11	12	11	34
28. Robot for Health-Related				
28.1 Overall Opinion				
28.1.1 Overall Attitude				
1. Positive	8	3	4	15
2. Positive and	0	1	1	2
3. Negative/don't see	1	1	2	4
4. Don't know/no	0	1	1	2
5. Other	0	0	0	0
6. Not mentioned	3	6	4	13
28.1.2 Benefit				
1. Benefit, general	2	2	2	6
2. Benefit to self	3	2	1	6
3. Benefit to others	3	2	3	8
4. Benefit to self	1	0	2	3
5. Not as much	0	0	1	1
6. More of	0	0	0	0
7. Not a lot/no	1	1	1	3
8. Other	1	0	0	1
9. Not mentioned	1	5	2	8
28.1.3 Feasibility				
1. Robot feasible	0	1	0	1
2. Robot not feasible	0	1	1	2
3. Don't know	0	0	1	1
4. Other	1	0	0	1
5. Not mentioned	11	10	10	31

Data from Interview Coding (cont')

Coding Dimension	N Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
29. Robot for Security: Tasks				
29.1 Tasks				
29.1.1 Emergency				
1. Mentioned	5	8	6	19
2. Not mentioned	7	2	6	15
29.1.2 Monitoring Home				
1. Mentioned	1	2	3	6
2. Not mentioned	11	8	9	28
29.1.3 Security System,				
1. Mentioned	12	10	10	32
2. Not mentioned	0	0	2	2
29.1.4 Security System,				
1. Mentioned	8	1	1	10
2. Not mentioned	4	9	11	24
29.1.5 Don't Know				
1. Mentioned	0	0	0	0
2. Not mentioned	12	10	12	34
29.1.6 Other				
1. Mentioned	0	1	2	3
2. Not mentioned	12	9	10	31
30. Robot for Security:				
30.1 Comparison to Original				
1. Robot has same	3	3	2	8
2. Robot has different	1	0	1	2
3. Robot more human-	1	0	0	1
4. Robot less human-like	0	0	0	0
5. Other	0	0	0	0
6. Not mentioned	7	7	9	23
30.2 Overall Appearance				
1. Human-like	3	5	0	8
2. Human-like and	1	0	0	1
3. Machine-	4	2	3	9
4. Looks like existing	1	2	1	4
5. Looks like	0	0	1	1
6. Looks like an animal	1	0	1	2
7. Other	0	0	2	2
8. Not mentioned	2	1	4	7

Data from Interview Coding (cont')

Coding Dimension	N			
	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
31. Robot for Security: Control				
31.1 Control, General				
31.1.1 Programmed				
1. General	4	5	6	15
2. Pre-	3	3	1	7
3. User-programmed	1	1	0	2
4. Both pre- and user-	0	0	1	1
5. Not mentioned	3	1	4	8
31.1.2 Direct Human				
1. Mentioned	1	2	1	4
2. Not mentioned	10	8	11	29
31.1.3 Don't know				
1. Mentioned	1	0	1	2
2. Not mentioned	10	10	11	31
31.1.4 Other				
1. Mentioned	2	0	0	2
2. Not mentioned	9	10	12	31
31.2 User-Directed Control,				
31.2.1 Input/Interface on				
1. Mentioned	0	1	2	3
2. Not mentioned	11	9	10	30
31.2.2 Remote Control/				
1. Mentioned	0	0	0	0
2. Not mentioned	11	10	12	33
31.2.3				
1. Mentioned	0	0	0	0
2. Not mentioned	11	10	12	33
31.2.4 Voice				
1. Mentioned	0	1	1	2
2. Not mentioned	11	9	11	31
31.2.5 Other				
1. Mentioned	1	2	0	3
2. Not mentioned	10	8	12	30
31.3 Sensors				
1. Mentioned	3	1	5	9
2. Not mentioned	8	9	7	24

Data from Interview Coding (cont')

Coding Dimension	N Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
32. Robot for Security: Overall				
32.1.1 Overall Attitude				
1. Positive	7	5	10	22
2. Positive and negative	1	1	0	2
3. Negative/don't see a	1	0	0	1
4. Don't know/no opinion	0	0	0	0
5. Other	0	0	0	0
6. Not mentioned	3	4	2	9
32.1.2 Benefit				
1. Benefit, general	5	2	3	10
2. Benefit to self	1	1	2	4
3. Benefit to others	0	2	1	3
4. Benefit to self under	1	0	0	1
5. Not as much benefit as	0	0	0	0
6. More of	0		0	0
7. Not a lot/no benefit	1	0	0	1
8. Other	0	1	0	1
9. Not mentioned	4	4	6	14
32.1.3 Feasibility				
1. Robot feasible	1	1	0	2
2. Robot not feasible	0	0	1	1
3. Don't know	0	0	1	1
4. Other	1	0	0	0
5. Not mentioned	10	9	10	30

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
33. Negative Characteristics of Robots				
33.1 Unwanted Robot Characteristics				
33.1.1 Aggressive/Turns Against				
1. Mentioned	5	0	0	5
2. Not mentioned	7	12	12	31
33.1.2				
1. Mentioned	5	5	7	17
2. Not mentioned	7	7	5	19
33.1.3 Damaging to Home				
1. Mentioned	1	2	0	3
2. Not mentioned	11	10	12	33
33.1.4 Difficult to Maintain				
1. Mentioned	4	6	3	13
2. Not mentioned	8	6	9	23
33.1.5 Difficult to Use				
1. Mentioned	1	1	0	2
2. Not mentioned	11	11	12	34
33.1.6 Expensive				
1. Mentioned	1	3	1	5
2. Not mentioned	11	9	11	31
33.1.7 Human-Like Appearance				
1. Mentioned	3	0	0	3
2. Not mentioned	9	12	12	33
33.1.8 Reasoning Ability				
1. Mentioned	4	0	0	4
2. Not mentioned	8	12	12	32
33.1.9 Uncontrollable				
1. Mentioned	5	2	4	11
2. Not mentioned	7	10	8	25
33.1.10 Don't Know				
1. Mentioned	0	1	1	2
2. Not mentioned	12	11	11	34
33.1.11 Other				
1. Mentioned	0	4	2	6
2. Not mentioned	12	8	10	30

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
		N		
34. Considerations before getting a				
34.1 Considerations before				
34.1.1 Capabilities of				
1. Mentioned	10	8	6	24
2. Not mentioned	2	4	6	12
34.1.2 Control/Ease of				
1. Mentioned	7	2	7	16
2. Not mentioned	5	10	5	20
34.1.3 Cost of Robot				
1. Mentioned	3	5	6	14
2. Not mentioned	9	7	6	22
34.1.4 Limitations of				
1. Mentioned	1	3	3	7
2. Not mentioned	11	9	9	29
34.1.5 Maintenance				
1. Mentioned	8	6	3	17
2. Not mentioned	4	6	9	19
34.1.6 Opinions of Others				
1. Mentioned	3	0	0	3
2. Not mentioned	9	12	12	33
34.1.7 Reliability of				
1. Mentioned	3	3	2	8
2. Not mentioned	9	9	10	28
34.1.8 Safety of Robot				
1. Mentioned	2	1	0	3
2. Not mentioned	10	11	12	33
34.1.9 Don't Know				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36
34.1.10 Other				
1. Mentioned	5	1	1	7
2. Not mentioned	7	11	11	29

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
35. Lifestyle Changes				
35.1 Lifestyle Changes				
35.1.1 No changes				
1. General	6	2	2	10
2. No changes,	0	1	3	4
3. Other	0	0	1	1
4. Not mentioned	6	9	6	21
35.1.2 Positive Changes				
1. Mentioned	5	4	2	11
2. Not mentioned	7	8	10	25
35.1.3 Neutral/General				
1. Mentioned	5	6	5	16
2. Not mentioned	7	6	7	20
35.1.4 Negative Changes				
1. Mentioned	3	1	1	5
2. Not mentioned	9	11	11	31
35.1.5 Don't Know				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36
35.1.6 Other				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36

Data from Interview Coding (cont')

Coding Dimension	Younger Adults	Younger-Older Adults	Older-Older Adults	Combined
	N			
36. Changes in Views/Opinions				
36.1 Changes in				
36.1.1 Views/Opinions				
1. Mentioned	5	6	4	15
2. Not mentioned	7	6	8	21
36.1.2 Change in Task				
1. More tasks/new	4	3	3	10
2. Fewer tasks/more	0	0	0	0
3. Other	1	0	0	1
4. Not mentioned	7	9	9	25
36.1.3 Change in				
1. Mentioned	1	0	1	2
2. Not mentioned	11	12	11	34
36.1.4 Change in				
1. Mentioned	1	0	0	1
2. Not mentioned	11	12	12	35
36.1.5 Change in Attitude				
1. Mentioned	1	1	0	2
2. Not mentioned	11	11	12	34
36.1.6 Never thought				
1. Mentioned	2	3	4	9
2. Not mentioned	10	9	8	27
36.1.7 Don't Know				
1. Mentioned	0	0	0	0
2. Not mentioned	12	12	12	36
36.1.8 Other				
1. Mentioned	0	0	2	2
2. Not mentioned	12	12	10	34

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